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THE NESTING ECOLOGY OF COOPER'S HAWKS AND NORTHERN GOSHAWKS IN THE JEMEZ MOUNTAINS, NM

A SUMMARY OF RESULTS, 1984-1988

BY

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INTRODUCTION

A study of the nesting ecology of the Cooper's Hawk (*Accipiter cooperi*) and Northern Goshawks (*A. gentilis*) in New Mexico was initiated during 1984 and continued through the winter of 1989. The objectives of the study were to evaluate

1. home range sizes of nesting birds;

2. habitat characteristics of nest sites;

3. prey selection patterns;

4. the distribution and population status of both species in the Jemez Mountains;

5. reproductive success in the Jemez Mountain population; and

6. develop management recommendations.

Results of the 1984 and 1985 field seasons are presented in Kennedy (1985; 1986; 1988). This report summarizes the findings of the four nesting seasons (1984-1986, 1988). In addition, management recommendations are presented which are based on the results of the 4-yr study.

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STUDY AREA

The study area is a 723 km^2 area in the Jemez Mountains, NM. It includes all of Los Alamos County, portions of Sandoval and Rio Arriba Counties, and the Rio Grande River on the San Ildefonso Pueblo. In

addition, habitat and reproductive success data were collected on Northern Goshawks in the Gila and Coronado National Forests during 1985. The two study areas are described in detail in Kennedy (1988).

METHODS

LOCATION OF NESTS

The methods for locating nests are described in Kennedy (1985).

POPULATION DENSITY ESTIMATES

To estimate nesting population densities of the two *Accipiter* species in the Jemez Mountains, a portion of the study area, Los Alamos County, was searched intensively for nests. The goal of the search was to obtain a complete count of nesting Accipiters in Los Alamos County. Los Alamos County was chosen as the intensive study area because topographical, physionomic, and land use data are available for the county on MOSS, a 32-bit Geographic Information System (GIS) at LANL.

Although vegetation types of Los Alamos County have not been digitized, forest cover class information has been digitized for 85.6% of the county area. The four cover classes are:

* Cover Class 1 - non-forested areas, e.g., urban areas, pinyon-juniper woodland;

* Cover Class 2 - forested areas with 10-40% canopy cover;

* Cover Class 3 - forested areas with 40-70% canopy cover; and

* Cover Class 4 - forested areas with >70% canopy cover.

The cover class database in MOSS is based on 1981 US Forest Service color aerial photographs (1:24,000 scale). The non-forested areas were mapped at a 2-ha resolution and the forested cover classes were mapped at a 18-ha resolution. All maps were ground-truthed extensively (Craig Allen, pers. comm.)

Nesting densities in Los Alamos County were calculated as the number of known nests per hectare of potential nesting habitat. The forest cover class information in the GIS was used to define acreages of potential nesting habitat.

Northern Goshawks in the southwest are known to avoid nesting in stands with <60% canopy cover (Crocker-Bedford and Chaney 1988). Based on this criterion, Cover Classes 3 and 4 were defined as potential nesting habitat for Northern Goshawks in Los Alamos County.

Cooper's Hawks are known to nest in a wide variety of habitats in New Mexico (Kennedy 1988) from open cottonwood stands to dense mixed conifer forests. Therefore, the three forested cover classes (2-4) were defined as potential Cooper's Hawk nesting habitat.

RADIOTELEMETRY DATA COLLECTION AND ANALYSES

Field Methods

Home range size and activity patterns were determined from observations of radio-tagged birds. Nesting pairs were trapped during the nestling period (mid-June-mid-July) and fitted with posture-monitoring transmitters made by Biotrack. Adults were trapped at the nest with Dho-gaza nets and a live Great Horned Owl (*Bubo virginianus*) or in hunting areas with bal-chatri traps baited with prey. Two, non-breeding, yearling, male Cooper's Hawks were also caught on bal-chatris and fitted with transmitters. Standard morphometric measurements were taken on each trapped bird and all nestlings that were banded.

A total of 33 transmitters were placed on Accipiters during 1984, 1986, and 1988 (Table 1). During 1984, radio transmitters were placed on three adult female Northern Goshawks, one adult male Northern Goshawk, three adult female Cooper's Hawks, and two adult male Cooper's hawks. At one Northern Goshawk nest and two Cooper's Hawk nests, transmitters were placed on both members of a pair.

During 1986, radio transmitters were attached to one adult male Northern Goshawk, one adult female Northern Goshawk, four adult female Cooper's Hawks, five adult male Cooper's Hawks, one immature female Cooper's Hawk, and one immature male Cooper's Hawk. At three Cooper's Hawk nests, transmitters were placed on both adults. With the exception of one immature male Cooper's Hawk (Bird 18), all birds were nesting.

In 1988, radio-transmitters were attached to one adult male Northern Goshawk, one adult female Northern Goshawk, five adult female Cooper's Hawks, two adult male Cooper's Hawks, and two immature male Cooper's Hawks. At one Northern Goshawk nest and two Cooper's Hawk nests, transmitters were placed on both adults. With the exception of Bird 33 (a fledgling male Cooper's Hawks), all birds were nesting.

During 1984 and 1986, all transmitters were tail-mounts. A detailed description of these transmitters is presented in Kennedy (1985).

Due to the problems of premature molting of the tail-mounts in 1986, I tested backpack mounts during 1988. Five of the transmitters used in 1988 were backpacks. I placed the backpacks on the two Northern Goshawks and on three of the female Cooper's Hawks. Backpacks were not placed on male Cooper's Hawks because they exceeded 3% of their body weight.

The backpack transmitters were purchased from L&L Electronics. The backpack attachment is described in Kenward (1987). The backpack transmitters weighed 12-15 g.

Transmitters operated for 7 days to 11 months before they either stopped transmitting, were molted by the birds, or were damaged by the birds. Transmitter frequency was 150-151 Mhz. Radio receiving equipment included an AVM Model LA-12 receiver; a Custom Electronics LA-12 receiver; a Custom Electronics Merlin receiver; a Biotrack receiver; two

hand-held, 3-element Yagi antennae; and two null peak antennae. The Yagi antennae were used for obtaining fixes from a distance and the null peak antennae were used for more accurate bearings once we were within 0.4 km of the bird.

During 1984, because a second receiver did not arrive until late July, the location of a bird was determined using two different techniques. These techniques are described in Kennedy (1985).

A minimum of two receivers were available at all times during 1986 and 1988. With two receivers, signals were monitored simultaneously by two observers, each equipped with a receiver, a Yagi antenna, and a null peak antenna. The simultaneous tracking of the radio-tagged birds provided more triangulated fixes on the birds' locations with a higher degree of accuracy when the null peak antennae were used. Location accuracy was checked by the visual observations.

Each bird was radio-tracked continuously for a 2-4-hr sampling period during all times of the day throughout a season. During each sampling period, the location of each observer was plotted on 7.5 USGS topographic maps and the compass position (in relation to magnetic North) of the bird from each observer was recorded. In addition, all visual observations of radio-tagged birds were plotted on the maps.

Data Analyses

The data were analyzed with two computer codes designed to analyze movement data. FIXX, a code developed on this project, was used to obtain animal locations from the field data and estimate a measurement error for each animal location based on distance of the observers from the bird and the known measurement accuracy of the receiving equipment. FIXX is described in detail in Kennedy (1985).

A second code, HOME RANGE, developed by Samuel et al. (1985), was used to analyze the home range areas of each bird. "Home range" has been defined as the area utilized by an individual during its normal activities such as food gathering, mating, and caring for young (Burt 1943). The key word in the above definition is "normal". Home range is not all the area that an animal traverses during its lifetime, but rather the area where it normally moves. Excursions to areas outside its normal range should not be considered part of the home range (Burt 1943). Therefore, objective criteria with a biological basis are needed to select movements that are "normal". The criterion used by HOME RANGE is to use a probability level; for example, the estimated home range includes the animal's locations 95% of the time. This leads to a more precise probability definition of home range: the probability of finding an animal at a particular location on a plane. This probability density function has been called the "utilization distribution" (Jennrich and Turner 1969; Samuel et al. 1985). The home range estimate is calculated by drawing equal height contours around the utilization distribution (White and Garrott 1987). The home range is specified by the contour such that 95% (or some other percentage) of the animal's locations are within the contour.

A detailed description of HOME RANGE is presented in Samuel et al.(1985). A summary of the HOME RANGE options that were used in this study are presented below.

Utilization Contours

These contours are based on the harmonic means calculated at grid points systematically located throughout the bird's home range. Harmonic means are nonparametric techniques that utilize one of several areal distributions that are described in detail by Neft (1966). The advantages and applications of harmonic means as a measure of activity are discussed by Dixon and Chapman (1980). The contours may be chosen as a specified percentage of the animal's utilization distribution or as a specified harmonic value (Samuel et al. 1985). For purposes of comparison with other studies, 95% and 75% contours were used in this study.

Core Areas

The concept of core areas has received considerable use in the ecological literature. The idea has generally been used to denote central areas of consistent or intense use (Kaufmann 1962). Conceptually, core areas have potential use as buffer areas around nest trees. However, a quantitative definition is noticeably absent. HOME RANGE identifies core areas by comparing the utilization distribution from harmonic mean calculations with a uniform use model (Samuel et al. 1985).

Outliers

Animals occasionaly wander from their normal activity areas. Such extreme locations generally plague most home range methods and Samuels et al. (1985) think that such observations should not be considered as part of the home range. Outliers typically represent transitional locations between seasonal use areas or are one-time excursions to areas beyond the boundaries of their normal home range. Outliers influence home range estimates by over-inflating the area. Outlying points have a dramatic effect on the large contours (e.g., 95%) but usually have smaller influence on the selection of lower percentage contours. Outliers also have less of an influence with large sample sizes than with small sample sizes and affect the selection of core areas.

HOME RANGE identifies outliers with three different procedures: 1) a binomial test of observation density; 2) a weighted bivariate normal technique; and 3) a list of points with large harmonic values.

HOME RANGE can estimate range size with other traditional methods commonly used in the literature, e.g., non-circular home range, minimum convex polygon. Recent papers have identified several problems with these commonly used techniques (Schoener 1981; Anderson 1982). These other methods were not used to estimate home range size of the nesting Accipiters for the reasons detailed below.

Non-circular Home Range

This is the traditional bivariate normal approach to home range analysis developed by Jennrich and Turner (1969). A major limitation to this technique is that it assumes the animal locations have a bivariate normal distribution and all locations have equal influence on the ellipse, including outliers.

Weighted Non-circular Home Range

This technique is a variation of the standard non-circular home range approach developed by Jennrich and Turner (1969). A bivariate normal distribution of animal locations is assumed, but locations that are far from the geometric center have a reduced influence on the home range ellipse.

Animal locations were tested for bivariate normality on HOME RANGE using a Cramer-von Mises goodness-of-fit test (Campbell 1980; Koziol 1982). Twenty-six of the 30 birds for which home range size could be estimated had location distributions that were significantly different from the bivariate normal distribution ($P \leq 0.05$). Thus, non-circular and weighted non-circular home range estimates were not calculated for the Accipiters because the distribution assumption was violated.

Convex Polygon

The oldest and most common method of estimating home range is the minimum convex polygon (Hayne 1949). The minimum area polygon is constructed by connecting the outer locations to form a convex polygon. The advantages of the convex polygon are 1) simplicity; 2) flexibility of shape; and 3) ease of calculation. However, there are a number of disadvantages. The major disadvantage is that the size of the home range estimate increases indefinately as the number of locations increases (Jennrich and Turner 1969) because the minimum convex polygon is estimating total area utilized, not the area utilized in normal movements. Two estimates are not comparable if one is based on 50 data points, while the second is based on 100 data points because the second estimate is expected to be somewhat larger (White and Garrott 1987). Minimum convex polygon estimates were not calculated because the number of locations obtained on each bird varied widely (Table 1).

Home range analyses were only conducted on birds for which a minimum of 20 independent locations were available (Table 1) (N=30). Newton (1986) found for European Sparrowhawks (*A. nisus*) that 20 locations were needed to estimate range size for the nesting period, and further locations did not improve the estimate significantly.

HABITAT EVALUATION

The habitat evaluation methodology is described in detail in Kennedy (1986; 1988).

FOOD HABITS

Accipiters regularly remove pelage and plumage from their prey in the nesting area or in the nest itself. These hawks regurgitate pellets,

and although most of the bone is digested, keratinized parts are not digested. On each visit to a nest site all remains and pellets found in plucking areas or in nests were completely picked up. Nests received 4-6 visits per month on the average during each nesting season.

During identification, all avian remains in a day's collection were lumped and reconstructed by matching remiges, rectrices, and bills. All mammal remains in a day's collection were also lumped and reconstructed by matching skull fragments and appendages. This procedure minimized the possibility of over counting the number of individuals of each species captured by the hawks.

Feather identification was based on comparison with the New Mexico Department of Game and Fish feather reference collections. Mammalian and avian bone fragments were identified by comparison with the synoptic collections of the Museum of Southwestern Biology at the University of New Mexico (UNM). Herpetological remains were identified by staff at the Herpetology Museum at UNM.

A total of 402 prey remains were collected during the study, 303 from Cooper's Hawk nests and 99 from Northern Goshawk nests.

Diets of raptors have been commonly determined from prey remains (Opdam 1975; Newton 1986; Reynolds and Meslow 1984) but the method is not entirely free of bias (Snyder and Wiley 1976). Hoglund (1964) found differences between prey from nest sites and those from stomachs of Northern Goshawks in Sweden. Snyder and Wiley (1976) found that collections of remains from nests gave biased estimates of the diets of the Red-shouldered Hawk (*Buteo lineatus*). Schipper (1973) showed that small birds and mammals are underestimated in prey remains of Harriers (*Circus* sp.). Additionally, plucks and nest remains may be biased toward the larger species. Smaller prey may be consumed by the adults away from the nest or delivered to the nest completely plucked. To examine this potential bias in the prey remain data, we analyzed castings and recorded prey deliveries at the nest.

Accipiter castings do not contain readily identifiable bones, e.g., mandibles, as do owl pellets. Therefore identifying the prey species in the castings was based on hair, feather, and scale identification. Because this is a very time-consuming process, a subset (N=237) of the over 800 castings collected during the study were analyzed; 150 Cooper's Hawk castings and 87 Northern Goshawk castings.

To prepare the castings for analysis, they were oven-dried at 76°C for approximately 48 hr. After drying, each casting was weighed to the nearest 0.01g on an electronic Mettler balance. The castings were dissected to separate the hair, feathers, and reptile scales.

One pellet can represent the remains from more than one meal. To determine the species representation in each pellet, 10 hairs and 10 feathers were systematically collected from each pellet for identification. Dorsal guard hairs and contour feathers that were not excessively damaged by digestion were selected. In addition, the

selection was systematic to identify all species in a pellet. Scales did not need to be sampled because they were not abundant in the pellets.

The selected hairs were cleaned in alcohol and xylene. The feathers were washed in a warm solution of Ivory Snow and water and rinsed in warm water.

Hairs were identified using taxonomic keys by Mathiak (1938), Mayer (1952), Adorjan and Kolenosky (1969), Moore et al (1974), and Tumlison (1983). In addition, the hairs were compared to reference hairs collected from specimens of probable prey species in the area. Hair could always be identified to family and in many cases to genus and species.

The tiny contour and down feathers found in Accipiter castings were sent to the US Fish and Wildlife Service National Fish and Wildlife Forensic Laboratory for identification. I have not received the results of these identifications, so the avian prey composition of the pellets will not be reported.

The reptile scales in the castings were identified to the generic and specific level by Howard Snell and his staff at the Herpetology Museum at UNM.

In addition, to the prey remains and pellet analyses, additional dietary information was collected by monitoring prey deliveries during 1986 and 1988. An observer was at the nest monitoring prey deliveries while the adults were being radio-tracked. A total of 155.3 hr were spent observing prey deliveries at five Northern Goshawk nests and 519.1 hr at 31 Cooper's Hawk nests. The analysis of that database is not completed and will not be reported. However, a preliminary analysis of the prey delivery data indicate that the common species being delivered at the nest were the common prey remains.

RESULTS

NESTING DENSITIES

The Northern Goshawk is an uncommon nesting species in the study area. Sixteen active Northern Goshawk nests or potential nest sites were located during the study. Seven of the 16 nests were located in Los Alamos County. Because of the intensive coverage I assume I located 90% of the Northern Goshawk nests in Los Alamos County.

The total acreage of Los Alamos County is 27,350.59 ha. The cover class distribution has been digitized for 85% of the county (23,422.72 ha). The northern portion of the county (north of Guaje Canyon) has not been digitized (Figure 1). The results of the following analyses assume the cover class distribution in the northern portion of the county is similar to the distribution in the digitized area.

Approximately 57% of Los Alamos County is forested (Figure 1). The remaining 43% are non-wooded habitats which include pinyon-juniper woodlands, urban areas, meadows, and shrublands. The total potential

nesting habitat for Northern Goshawks comprises 44.2% of the county (12,101.99 ha). Forest Cover Class 2 comprises 12.9% of the county area.

The estimated nesting density of Northern Goshawks in Los Alamos County is one pair/1,571.7 ha of potential nesting habitat. or 6.36 pairs/100 km^2. This estimate assumes there are 7.7 nests (90% coverage = 7 nests) in 12,101.99 ha of nesting habitat. If the nesting density is expressed in terms of the total acreage of Los Alamos County, there is 1 pair/3,552.02 ha or 2.82 pairs/100 km^2.

The Cooper's Hawk is a common nesting species in the study area; 37 nest sites were located during the four years. Twenty-one of the 37 Cooper's Hawk nests were located in Los Alamos County. The total potential nesting habitat in Los Alamos County is 15,623.51 ha. Assuming we located 90% of the nests in Los Alamos County, the nesting density of Cooper's Hawks is 1 pair/676.3 ha or 14.8 pairs/100 km^2 of potential nesting habitat.

The Accipiter nesting densities calculated for Los Alamos County probably represent maximum nesting densities for the Jemez Mountains because the analysis assumes all nest sites are active during one year. In fact, all sites are not occupied every year. Various factors affect site occupancy including, site disturbances, reproductive failures, and the death of a mate.

Because new Accipiter nests were located every year in the Jemez Mountains and all nests were not monitored every season, it is difficult to quantify the annual site occupancy rates. If we assume 70% of the Accipiter sites in Los Alamos County are active annually, the corrected nesting densities are 4.45 Northern Goshawk pairs/100 km^2 and 10.4 pairs of Cooper's Hawks/100 km^2 of potential nesting habitat.

POPULATION TRENDS

Population trends for both Accipiter species are difficult to evaluate due to a paucity of historical data. The results of this study can be used as baseline for future studies and monitoring efforts. However, the relative "health" of this Accipiter population can be inferred from comparisons with other populations (Table 2). The estimates in Table 2 are based on total acreages within each study area. They have not been corrected for acreages of non-nesting habitat and occupancy rates. Therefore, the densities based on total Los Alamos County acreage will be used for comparison.

Cooper's Hawk nesting densities range from a high of 14.9 pairs/100 km^2 in Utah to 4.3 pairs/100 km^2 in northwestern Oregon. The Cooper's Hawk nesting density in Los Alamos County is in the middle of this range of population densities. This is an indication of a healthy population, assuming the high densities recorded in other areas also represent healthy populations.

Northern Goshawk densities range from a high of 11 pairs/100 km^2 in northern Arizona to a low of 2.4 pairs/100 km^2 in Alaska (Table 2). Except for the Arizona densities, these figures are also comparable to

the densities recorded for the European subspecies (*A. g. gentilis*) (Table 2).

The Northern Goshawk population in the Jemez Mountains is lower than most published records. This is particularly apparent when you compare these densities with density estimates for the Kaibab Plateau in northern Arizona (11 pairs/100 km^2). This area is similar ecologically to the Jemez Mountains, but has not been managed for timber as intensively. Under similar management strategies, these two areas should support similar Northern Goshawk nesting densities.

Crocker-Bedford and Chaney (1988) estimated that logging on the North Kaibab has resulted in a 50% reduction from an estimated historical population of 130 pairs (22 pairs/100 km^2). The highest density estimate calculated for the Northern Goshawk in the Jemez Mountains (6.36 pairs/100 km^2) is 58% of the North Kaibab's current nesting population. If Crocker-Bedford and Chaney's historical estimate for the North Kaibab is representative of historical populations in the Jemez Mountains, the Northern Goshawk population in the Jemez Mountains has declined by 71.1%

AGE STRUCTURE OF THE POPULATION

All Northern Goshawks observed and trapped at nests were adults. Of the 37 nesting pairs of Cooper's Hawks, three females (8.1% of all nesting females) and one male (2.7% of all nesting males) were yearlings. The remaining 70 birds (89.2%) were older than two years. Of the 27 Cooper's Hawks trapped at nests, three (11.1%) were yearlings, five were 2 years old (18.5%) and 19 were older than two years (70.3%).

REPRODUCTIVE BIOLOGY

The reproductive success of the Northern Goshawks in this study is presented in Table 3. The data in Table 3 are based only on those nests that were monitored regularly until fledging. The data includes nesting attempts from the same sites over several years. No egg counts were taken, so hatching success cannot be estimated.

The nestling mortality rate for Northern Goshawks was 25%. The number of fledged young per successful nest was 2.14. However, the number of fledged young per nesting attempt was quite low (0.94), compared with the reproductive success of Northern Goshawks in other areas (Table 4). This low reproductive success combined with low densities, suggests the Northern Goshawk population in the Jemez Mountains could be declining and active conservation measures should be implemented by management agencies.

Clutch initiation (calculated from observations of incubating birds and backdating from the date of hatching) ranged from April 24 - May 10 for Northern Goshawks. The nestling period was 35-40 days. The fledglings were recorded at all nest sites until at least late August. This results in a minimum fledgling dependency period of 8 weeks. The sex ratio of banded Northern Goshawk nestlings was 3:1 (females:males).

The reproductive success of the Cooper's Hawks in the Jemez Mountains during 1984-1988 is presented in Table 3. The only data collected on hatching success was an egg count done at one nest. This nest contained four eggs just prior to hatching. However, only 3 nestlings were recorded in the nest a few days after hatching. The nestling mortality rate was 14%. The number of fledged young per successful nest was 2.36 and the number of young per nesting attempt was 2.03. This is similar to the reproductive success recorded in other US populations (Table 4). Based on the nesting density and reproductive success data, the Cooper's Hawk population in the Jemez Mountains appears to be stable.

Clutch initiation for Cooper's Hawks ranged from May 10 - May 30. Double clutching was recorded at one Cooper's Hawk nest during 1986. The nest had an incubation failure in mid-May but the female laid another clutch about two weeks later and fledged two young.

The nestling period was 28-32 days. The fledglings were regularly recorded at all nest sites until early September. This results in a minimum fledgling dependency period of 8 weeks.

The sex ratio of banded nestlings and fledglings was 26:14 (female:male). The preponderance of females in the Accipiter populations is curious. It may be an artifact of sample size or it may reflect a higher female mortality.

HOME RANGE CHARACTERISTICS

During the three nesting seasons,32 Accipiters were radio-tracked (Table 1). One female Cooper's Hawk (Bird 10) was trapped at the same nest site during 1986 and 1988 and tracked during both field seasons. One female Northern Goshawk (Bird 28) was tracked for almost a complete year due to unusual battery duration. A total of 2,902 separate Accipiter locations with acceptable error estimates (see discussion below) were obtained during the 903.4 hr of tracking. The nine mated pairs that were tracked are indicated in Table 1 and in Figures 2-33.

The optimum home range estimate would be based on the maximum accuracy of locations (e.g., sighting of individuals; zero measurement uncertainty) and the optimum number of locations. However, due to the equipment limitations, rough topography, secretive nature of the birds, and their rapid continual movement, an accuracy of less than 250 m for all fixes is difficult to obtain. However, at a maximum accuracy of 250 m, on the average, 25% of the locations are eliminated resulting in small sample sizes for home range estimates.

To develop a reliable and representative estimate of the home range size for each bird, ranges were calculated using locations (N=2,902; Table 1) with measurement accuracies ranging from 10 m to 1 km. This means that the home range estimates with a maximum measurement uncertainty of 1 km include all locations with a measurement accuracy of <1 km. Examples of this error analysis and a detailed description of the analysis conducted by FIXX are presented in Kennedy (1985).

Harmonic mean home range estimates calculated with HOME RANGE are presented in Tables 5-7. Outliers were not included in the home range estimates. Both 95% and 75% contours are presented. In addition, core areas were estimated. These core areas have significant management implications which will be discussed in the Summary and Management Recommendations Section.

Home range sizes were only calculated for birds with a minimum of 20 locations (N=31) (Table 1). In addition, the home range estimates for Bird 11 (mate of Bird 10) do not reflect his true range size because he damaged his antenna. His signal could not be received unless we were within 0.1 km. Thus, his locations were all close to the nest and at roost sites. His hunting areas were not discovered.

Plots of the individual home ranges are presented in Figures 2-33. The plots were generated with Cricket Graph, a graphics package on a Macintosh II. Contours are plotted for each home range estimate in Tables 5-7. The axes of the plots reflect the metric distance from the central point in the study area (0 km N-S, and 0 km E-W). The central point in the study area was arbitrarily chosen as the SW corner of the Guaje Mountain USGS quadrangle. Negative numbers are the number of kilometers west and south of the central point. Positive numbers are the number of kilometers east and north of this central point.

Individual home ranges are generally plotted at scales appropriate to show the bird's movement. The same scale could not be used for all individuals because home range sizes were so variable.

On the average, the female Cooper's Hawks had the largest home range (mean = 2,802.9 ha Table 6), followed by the male Northern Goshawks (mean = 2106.3 ha Table 5), and male Cooper's Hawks (mean = 1,205.9 ha Table 7). Female Northern Goshawks had the smallest home ranges (mean = 569.3 ha Table 5). However, range size varied enormously. The biggest variation in range size was exhibited by female Cooper's Hawks. Bird 09 (an adult female Cooper's Hawk) had the smallest range size (87.3 ha) and the largest range size was occupied by a female Cooper's Hawk (Bird 10 in 1986 - 13,309.4 ha). This variation in female Cooper's Hawk ranges is a result of whether or not they desert and go to pre-migratory areas.

Females 10, 16, 26, and 30 deserted their mates when the young were 6-7 weeks of age. Mate desertion is assumed to have occurred in three other cases (Bird 9, Bird 5, Bird 13) where the female left the nest area when the young were 6-7 weeks of age. These three females were not relocated because they probably traveled out of the range of our tracking devices. The desertions observed in female Cooper's Hawks are the first documented cases of mate desertion in monogamous Falconiformes.

The large variation in Accipiter range size is also probably a result of 1) experience of the bird; 2) food requirements (which varies seasonally); and 3) prey availability surrounding the nest.

The majority of the tagged birds in this study were tracked during the period in the nesting season when food requirements are maximum (feeding nestlings and fledglings). Newton (1986) found the smallest home ranges occurred during the courtship and incubation periods. Bird 23 (a male Cooper's Hawk) was trapped during incubation and he molted his transmitter before hatching. He had one of the largest range sizes of the male Cooper's Hawks which would contradict Newton's findings. However, Bird 23 was a yearling and his lack of experience could account for his large range size.

I would predict that birds nesting in good habitat have smaller home ranges than birds nesting in poorer or marginal habitats. Newton (1986) found in European Sparrowhawks that the more plentiful the prey, the more sedentary the individuals became, and the sparser the prey, the more wide-ranging they became.

Major vegetation changes such as logging, may impact Accipiter home range size by changing good quality hunting habitat to more marginal habitat. This hypothesis is difficult to test statisticly because there is no quantitative historical database on the frequency and extent of timber treatments within the birds' ranges. In addition, home ranges should only be compared between birds hunting in similar habitats which reduces the sample size considerably. This is particularly true for the Cooper's Hawks which hunted pinyon-juniper woodland, riparian zones, Ponderosa Pine, and mixed conifer. In addition, the male Cooper's Hawk range sizes are probably a function of the females' participation in feeding the young. A deserted male probably has a larger range than a male that shares the hunting role with the female.

The impacts of logging on Accipiter ranges can be examined by comparing the range sizes of the Northern Goshawks which appear to have a less complex nesting strategy than the Cooper's Hawks. The three male Northern Goshawks tagged in this study hunted predominantly in Ponderosa Pine habitat, and provided most of the prey during the nestling stage so a comparison between them is valid.

Male 01 was hunting in an area that was being logged extensively during 1984 and was logged once during the 1950's. Both sales were "pick and pluck" sales which removed many of the larger trees (Mike Morrison, pers. comm.). Male 22 and Male 27 were nesting in areas that have not been cut in over a decade and the previous cuts were salvage sales in which old, dying trees such as snags are removed (Dwight Devarro, pers. comm.).

The home range of Male 01 (2,837 ha) which nested in an area that has been managed extensively for timber in recent years, is quite a bit larger than the home range of the other two males (Bird 22 - 1,784 ha; Bird 27 - 1,697 ha) which are nesting in less managed sites. In addition, the degree of management in the nesting areas of Birds 22 and 27 has been similar and this is evident in their comparable range sizes.

The nest site occupied by Birds 01 and 02 was logged during the winter of 1984-85. The birds attempted to renest in the site in 1985, failed during incubation and the site has not been occupied since 1985.

Both sites occupied by Males 22 and 27 have continued occupancy since 1986 when they were located.

In addition, Cooper's Hawk Male 15 was nesting in close proximity to Birds 01 and 02 within the same timber sale, in a drainage that was not cut. We tagged and tracked him in 1986 after the sale was completed. His range size was over twice as large as the ranges of the other male Cooper's Hawks (Table 7).

Many of the home range boundaries appear to also be influenced by topographic features. For example, the eastern and western boundaries of the home ranges for Bird 01 and Bird 02 correspond with two major perennial drainages. The northeastern boundary of Bird 03's home range is also a large canyon drainage. Other examples can also be noted if one overlays the plots onto topographic maps. It is possible, however, that these boundaries reflect prey distribution changes rather than physical barriers.

The home range boundaries do not appear to be established by intra- or interspecific territorial spacing. The home ranges of many nesting Accipiters overlap. The extensive overlap between pairs of Cooper's Hawks suggest that for this species, density estimates based on non-overlapping home range boundaries or mean spacing distances may significantly underestimate their actual population density. However, overlap between core areas is much less, so non-overlapping core area distributions may be an adequate density estimation technique.

Comparisons of home range sizes between Accipiter populations cannot be done because radio-tracking data of nesting Accipiters are not available. Murphy et al. (1988) have the only published data on radio-tagged Accipiters and they only have data for one nesting male Cooper's Hawk in Wisconsin. They reported a nesting range size of 784 ha which is comparable to some of the estimates for the male Cooper's Hawks in this study. No published home range sizes exist for nesting Northern Goshawks.

Core areas that include the nest (Tables 5-7) averaged 167.9 ha for female Northern Goshawks, 648.7 ha for male Northern Goshawks, 403.9 ha for female Cooper's Hawks, and 341 ha for male Cooper's Hawks. These core areas represent concentrated use areas and include, preferred hunting areas near the nest, perches, roost sites, and training areas for the fledglings. Several birds (See Figures 11 and 12 for examples) had multiple core areas. The core areas away from the nest were other preferred hunting areas or roost sites.

The females' core areas that include the nest is what I refer to as the nest stand. Previous investigaters have defined nest stands by vegetation and topographic characteristics rather than bird usage patterns (Shuster 1980; Reynolds 1983). The females' core areas include the major plucking posts, perches, and the areas used by the fledglings during the fledgling dependancy period. These are the areas that should be protected from habitat disturbance and will be the basis of the buffer zone recommendations presented in the SUMMARY AND MANAGEMENT RECOMMENDATIONS SECTION of this report.

HABITAT SELECTION FOR NESTING

The nest site selection patterns of nesting Accipiters are discussed in Kennedy (1986; 1988). These papers are based on habitat data collected during 1984 and 1985. No additional habitat data were collected in 1986 and 1988.

FOOD HABITS

In this study area, Northern Goshawks ate even proportions of birds and mammals while the Cooper's Hawk preyed more heavily on birds. Cooper's Hawks in this area also captured reptiles which were not taken by the local Northern Goshawks (Tables 8-9).

During 1984-88, a minimum of 298 individual birds were recorded at Accipiter nest sites (Table 8). The Northern Flicker (*Colaptes auratus*), American Robin (*Turdus migratorius*), and Stellar's Jays (*Cyanocitta stelleri*) were the most frequently encountered avian prey at Accipiter nest sites. In addition, Mourning Doves (*Zenaida macroura*) were commonly taken by Cooper's Hawks.

The prey remains data indicate 15 and 26 avian prey species were taken by Northern Goshawks and Cooper's Hawks, respectively. The greater prey diversity of the Cooper's Hawks is a result of the wider variety of habitats occupied by this species (Kennedy 1988).

According to the prey remains data, the most common mammals in the Northern Goshawk diet were rabbits (*Sylvilagus* sp.) and tree squirrels (*Sciurus aberti* and *Tamiasciurus hudsonicus*) (Table 8). The casting data also indicate that tree squirrels were common Northern Goshawk prey but the Golden-mantled Ground Squirrel (*Spermophilus lateralis*) was more common in the castings than rabbits (Table 9).

The Cooper's Hawks prey heavily on chipmunks (*Eutamias* sp.), a prey species not commonly taken by Northern Goshawks probably because of their small size (Tables 8-9). However as with the avian prey, there is extensive overlap in the mammal prey taken by both Accipiters. The Cooper's Hawk commonly hunts tree squirrels and rabbits. Although they take more juvenile animals and the Goshawks take more adults, we have observed Cooper's Hawks deliver pieces of adult rabbits and Abert's Squirrels. One female Cooper's Hawk was observed flying into the nest stand with the dorsal half of a rabbit. She dropped it and it was weighed. The dorsal half of the rabbit weighed 275 g. The total rabbit probably weighed over 400g and the female weighed 375g at the time of capture.

Bird and mammal populations are affected by changes in 1) tree species composition; 2) tree age, size and spacing; 3) canopy volume; and 4) species composition and density of the understory (Franzreb and Ohmart 1978; Szaro and Balda 1979; Patton et al. 1985; Sullivan and Moses 1986). Changes in prey availability may affect the numbers of breeding hawks and their reproductive performance. Alterations in the

size-frequency structure of the food resource in areas of sympatry may change the intensity of competition for food among these hawks (Reynolds and Meslow 1984) and may result in a population reduction or the exclusion of a species (Reynolds 1988).

In this study area several prey species occur in the upper prey-size range of the Cooper's Hawk and in the lower size range of the Northern Goshawk. Because some of these prey are relatively abundant, e.g., Northern Flickers, Abert's Squirrels, they are dominant species in the diet of both hawks. These species, by virtue of their abundance, are "buffers" which probably facilitate the coexistence of the two species (Reynolds 1988).

Populations of two buffer species, the Red Squirrel and the Abert's Squirrel, are sensitive to tree harvests (Patton et al. 1985; Sullivan and Moses 1986); squirrel numbers decrease by as much as five times after thinning unmanaged pine forests (Sullivan and Moses 1986). Depending on the availability of the alternative prey for the coexisting Accipiters, changes in these squirrel populations may alter the relative abundance of the Cooper's Hawks and Northern Goshawks. My prediction is that if squirrel populations decline in this area, so will the Northern Goshawk populations. Cooper's Hawks, which take a wider variety of prey than the Northern Goshawk, would probably show a functional response rather than a numerical response and prey more heavily on chipmunks and common avian species.

SUMMARY AND MANAGEMENT RECOMMENDATIONS

Because the Cooper's Hawk and Northern Goshawk may be vulnerable to changes in forest sites resulting from timber harvesting, to minimize the impacts to these nesting Accipiters in the Southwest, the following recommendations are proposed. These recommendations are based on the results of this study, Kennedy (1988), and Forest Service published recommendations (Reynolds 1983).

* Search all proposed timber sales for Accipiter nests. Potential nest sites cannot currently be predicted based on vegetation data (Kennedy 1988), so nest searches are necessary. Searches are best conducted during courtship (mid-late April - Northern Goshawk; early May - Cooper's Hawk) or the nestling and fledgling dependency periods (June - July - Northern Goshawk; late June - early August - Cooper's Hawk) when the birds are the most vocal. Recordings of adult and begging juvenile vocalizations broadcasted in potential sites would facilitate this process.

Rosenfield et al.(1988) found that during the nestling stage, broadcast recordings of Cooper's Hawk vocalizations (vs equal search effort without tapes) can markedly increase the chance of detecting Cooper's Hawks near their nests. Rosenfield et al. (1985) found that broadcasts during pre- and post-incubation were more likely to elicit a response than broadcasts during incubation. In addition, they found that most responses to broadcasts were noted >50m and < 112 m from the nest. They concluded that responses to taped calls suggest that an observer is within 100 m of a Cooper's Hawk nest.

I have effectively used tapes to locate Accipiter nests in this study area but the technique needs to be tested quantitatively before survey guidelines can be developed. In particular, the effectiveness of broadcast calls in locating Northern Goshawk nests needs to be tested.

* Based on densities and reproductive success, the Northern Goshawk population in northern NM is threatened. To insure the species does not exhibit further population declines, a 648 ha (1600 acres) Northern Goshawk area should be located around active nests. This area is based on the average core area size of nesting male Northern Goshawks (Table 5). Within this area, a 168 ha (415 acre) core should be identified that includes the nest, favorite perches, and plucking posts. This is the core area average for female Northern Goshawks (Table 5). The shape of this core area is dictated by the local topography and the habitat usage patterns of individual birds. For example, a nest within the bottom of a canyon will probably have a core area that is elliptical and includes the canyon bottom, both steep slopes and the perches on the rim.

* No silvicultural and other land management practices that would result in a habitat change should occur in these "female" core areas. The remaining 480 ha (1185 acres) in the Northern Goshawk area could sustain limited management activities outside of the breeding season. Locations for activities and cutting units for timber sales would be identified using a process similar to the one being implemented for the Mexican Spotted Owl (*Strix occidentalis*).

* The breeding season for the Northern Goshawk is defined as April 15 - August 30 with options to adjust the ending date if annual reproduction has not occured by June 1. If nesting does not occur by June 1, it is safe to assume that they will not nest that year, so planned management activities could continue after June 1.

* Within the zone outside of the core area, management should favor treatments that do not reduce canopy coverage below 60% and minimizes the removal of large live trees and snags. Kennedy (1988) recommends a minimum of 10 snags/ha (4 snags/acre) be maintained near Northern Goshawk nest sites.

* In Northern Goshawk areas where commercial thinning occurs, brush piles should be created to provide habitat for medium-sized mammals, e.g., cottontails and Golden-mantled Ground Squirrels, mammalian prey of New Mexico Northern Goshawks.

* The Cooper's Hawk population in the Jemez Mountains is not currently threatened. so less conservative management practices can be implemented. However, some management is required to insure the species does not become threatened as it has in the midwest. I recommend a core area of 20 ha be established around active Cooper's Hawk sites. This is the smallest core area size recorded for a nesting female Cooper's Hawk (Table 6). No silvicultural or other land management activities should be allowed in these core areas.

* The effects of these buffer zones should be monitored for several years to insure they are accomplishing their purpose: maintenance of an active territory.

* Fire management practices should not be conducted within the proposed core areas during the nesting season (April-August). Burns could be conducted in the core areas in the fall, if they do not involve road construction.

* Periodic monitoring (every 2-3 years) of known Accipiter nests should be conducted to evaluate population trends.

* The adult Northern Goshawk is a resident in this area and overwinters near nest sites (Figures 27 and 28). Winter habitat may be as critical to their population stability as nesting habitat. Studies of the over-winter survival of juvenile and adult Northern Goshawks as well as their winter habitat and prey selection patterns should be implemented to develop management guidelines for winter habitat.

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TABLE 1. CODE NAMES, DURATION OF TRACKING PERIOD, AND NUMBER OF SEPARATE LOCATIONS OF RADIO-TAGGED NORTHERN GOSHAWKS AND COOPER'S HAWKS IN THE JEMEZ MOUNTAINS, NM.

CODE	NAME	TRACKING PERIOD	NO. HR. TRACKING[A]	NO. LOC
NORTHERN GOSHAWKS				
1[B]	MALE	6/13-8/28/84	44.2	62
2[B]	FEMALE	6/6-8/11/84	27.5	57
3	FEMALE	6/8-8/3/84	30.6	46
7	FEMALE	7/13-8/18/84	21.8	69
19	MALE	7/23-10/25/86	54.2	184
22	FEMALE	7/25-9/22/86	36.4	157
27[B]	MALE	6/16-8/19/88	27.6	100
28[B]	FEMALE	6/9/88-5/16/89	83.6	367
COOPER'S HAWKS				
4	FEMALE	7/1-8/13/84	18.3	55
5[B]	FEMALE	7/2-8/3/84	14	62
6[B]	MALE	7/12-8/26/84	21.6	76
8[B]	MALE	7/5-8/24/84	23	58
9[B]	FEMALE	7/10-8/2/84	12	22
10[B]	FEMALE	7/10-8/30/86	60	300
		6/27-9/22/88	50.3	113
11[B,C]	MALE	7/10-8/4/86	17.9	39
12	FEMALE	7/3-7/30/86	19.2	38
13[B]	FEMALE	7/12-8/8/86	16.8	44
14[C]	MALE	7/12-8/8/86	13.4	65
15	MALE	7/11-10/8/86	56.2	177
16[B]	FEMALE	7/24-10/1/86	67.2	211
17[B]	MALE	7/24-8/6/86	9.1	31
18[C]	MALE	7/13-7/21/86	6.4	20
20[C]	FEMALE	8/11-8/18/86	5.5	5
21[C]	MALE	8/4-8/26/86	10.7	24
23	MALE	5/27-6/13/88	27.6	85
25[B]	MALE	6/20-7/21/88	9	26
26[B]	FEMALE	6/28-9/9/88	29	137
29	FEMALE	7/12-9/22/88	40.9	108
30[B]	FEMALE	6/30-8/18/88	13.3	22
31	FEMALE	7/22-8/17/88	16.4	62
32[B,C]	MALE	6/29-7/6/88	9.6	68
33[D]	MALE	9/1-9/15/88	10.1	12

A. This does not include time spent in the radio-tracking periods during which the birds could not be located.

B. The mate of this bird is also radio-tagged.

C. The radio transmitter on this bird failed prematurely or was molted early so few locations were obtained for this individual.

D. This bird migrated soon after radio attachment.

TABLE 2. NEST DENSITIES (NESTS/100 KM^2) OF *ACCIPITER* IN THE US.

STUDY	LOCATION	NESTS/100 KM^2
NORTHERN GOSHAWK		
McGowan, 1973	Alaska	0.3-2.4[A]
Shuster, 1980	Colorado	7.4
Reynolds and Wight, 1978	Oregon, S	3.6
Bloom et al., 1986	California	1.1-3.2[B]
Crocker-Bedford and Chaney, 1988	Arizona	11.0
This Study	New Mexio	2.8
EUROPEAN GOSHAWK		
Hoglund, 1964	Finland	1.0-4.5[A]
Hakila, 1968	Finland	6.1
Widen, 1985	Sweden	3.0
COOPER'S HAWK		
Reynolds and Wight,1978	Oregon, NW	4.3-5.4[A]
	Oregon, S	4.5
Fischer (in Reynolds,1988)	Utah	14.9
This Study	New Mexico	8.4

A. Variation across years
B. Variation across habitat.

TABLE 3. REPRODUCTIVE SUCCESS OF NORTHERN GOSHAWKS AND COOPER'S HAWKS IN NEW MEXICO DURING 1984-1988

PARAMETER	GOSHAWK[A]	COOPER'S HAWK
Nesting Attempts (N)	16	29
% Successful[B]	43.7	86.2
Total Nestlings (N)[C]	20	69
Total Fledglings (N)[C]	15	59
Nestling Mortality (%)	25	14.5
# Young/successful nest	2.14	2.36
# Young/nesting attempt	0.94	2.03

A. The Northern Goshawk data includes 1984-86 and 1988 data from the Jemez Mountains and 1985 data from southern New Mexico.

B. A successful nest is one that fledges young.

C. The total number of nestlings or fledglings counted at all active nests during this stage.

TABLE 4. NUMBER OF YOUNG FLEDGED PER NEST ATTEMPT OF NORTHERN GOSHAWKS AND COOPER'S HAWKS IN THE US.

STUDY	LOCATION	YEARS	PRODUCTIVITY
NORTHERN GOSHAWKS			
McGowan, 1973	Alaska	1971-73	2.00 (33)[A]
Reynolds and Wight, 1978	Oregon	1969-74	1.70 (48)
Herron et al., 1985	Nevada	1976-81	2.2 (88)
Bloom et al., 1986	California	1981-83	1.70 (127)
Fischer (in Reynolds, 1988)	Utah	1979-85	3.0 (10)
This Study	New Mexico	1984-88	0.94 (16)
COOPER'S HAWKS			
Craighead and Craighead,1956	Michigan	1942	2.00 (6)
		1948	2.30 (7)
Henny and Wight, 1972	NE US	1929-45	3.53 (118)
		1949-67	2.67 (54)
Reynolds and Wight, 1978	Oregon	1969-74	2.10 (24)
Herron et al., 1985	Nevada	1976-81	2.6 (?)
Fischer (in Reynolds, 1988)	Utah	1979-85	2.5 (19)
This Study	New Mexico	1984-86	2.03 (29)

A. Number in parentheses is number of nests.

TABLE 5. HARMONIC MEAN ESTIMATES OF HOME RANGE SIZE FOR RADIO-TAGGED NORTHERN GOSHAWKS IN NORTHERN NEW MEXICO, 1984-1988. AREAS PRESENTED CONTAIN 95% AND 75% OF HAWK LOCATIONS AS WELL AS A CORE AREA.

	HARMONIC MEAN ESTIMATES (ha)		
HAWK	CORE AREAS[A]	75%	95%
MALE 01	1,032.9	1,687.3	2,837.2
FEMALE 02	63.4	110.0	223.8
FEMALE 03	141.8	271.0	507.3
FEMALE 07	34.0	59.8	94.8
FEMALE 19	271.5	510.7	729.0
MALE 22	418.7	1,241.7	1,784.2
	160.8		
	18.1		
MALE 27	494.4	889.4	1,697.5
FEMALE 28			
SUMMER[B]	328.6	747.1	1,291.5
	55.3		
WINTER[C]	460.7	655.0	1,231.8
MEAN FEMALES	167.9[D.]	339.7	569.3
SD	128.5	287.7	473.1
MEAN MALES	648.7[D.]	1,272.8	2,106.3
SD	334.9	399.9	634.5
MEAN GOSHAWKS	348.2[D.]	770.3	1,145.7
SD	321.6	502.7	935.8

A. Individual core areas are listed separately. If a bird has more than one core area, the core area containing the nest is listed first. The other core areas represent preferred hunting or roost sites.

B. These estimates are based on data collected from 6/9/88 to 9/30/88.

C. These estimates are based on data collected from 10/1/88 to 5/16/89 and are not included in the means.

D. The mean core area only includes the core areas that include the nest.

TABLE 6. HARMONIC MEAN ESTIMATES OF HOME RANGE SIZE FOR RADIO-TAGGED FEMALE COOPER'S HAWKS IN NORTHERN NM, 1984-1988. AREAS PRESENTED CONTAIN 95% AND 75% OF THE HAWK LOCATIONS AS WELL AS A CORE AREA.

	HARMONIC MEAN ESTIMATES (ha)		
HAWK	CORE AREAS[A]	75%	95%
FEMALE 04	87.7	209.1	305.2
FEMALE 05	106.2	152.6	255.0
FEMALE 09	22.6	45.6	87.3
FEMALE 10			
1986	544.9	5,075.0	13,309.4
	2,133.2		
1988	277.5	1,239.4	2,269.8
	352.6		
	20.5		
FEMALE 12	88.0	133.8	210.6
FEMALE 13	46.0	81.2	226.6
FEMALE 16	181.7	3,199.5	5,470.3
	1,510.8		
	46.0		
FEMALE 26[B]	72.5	131.1	297.0
FEMALE 29	539.5	732.0	1,242.9
FEMALE 30	2,446.9	4,945.1	8,620.5
FEMALE 31	432.9	791.7	1,340.6
	53.3		
MEAN	403.9[C]	1,394.7	2,802.9
SD	670.8	1,904.9	4,220.6

A. Individual core areas are listed separately. If a bird has more than one core area the core area containing the nest is listed first. The other core areas represent preferred hunting or roost sites.

B. This female damaged her antennae after deserting her mate which reduced her transmitter range to <0.2 km. As a result her range size is artificially small.

C. The mean core area only includes the core areas that include the nest.

TABLE 7. HARMONIC MEAN ESTIMATES OF HOME RANGE SIZE FOR RADIO-TAGGED MALE COOPER'S HAWKS IN NORTHERN NM, 1984-1988. AREAS PRESENTED CONTAIN 95% AND 75% OF THE HAWK LOCATIONS AS WELL AS A CORE AREA.

	HARMONIC MEAN ESTIMATES (ha)		
HAWK	CORE AREAS[A]	75%	95%
MALE 06	170.1	299.9	534.3
MALE 08	199.9	390.2	655.2
MALE 11[B]	4.8	7.8	19.1
MALE 14	598.5	1,154.3	1,899.6
MALE 15	857.6	1,606.0	3,032.3
MALE 17	291.9	385.5	835.1
MALE 18[C]	27.6	54.8	105.0
MALE 21	98.7	332.3	576.6
MALE 23	538.0	908.3	2,378.5
	24.7		
MALE 25	38.7	63.9	168.6
MALE 32	275.3	377.3	773.3
MEAN[D]	341.0[E]	618.5	1,205.9
SD	268.8	493.0	983.8

A. Individual core areas are listed separately. If a bird has more than one core area the core area containing the nest is listed first. The other core areas represent preferred hunting or roost sites.
B. This male damaged his antennae which reduced the transmitter range to <0.2 km. As a result his range size is artificially small.
C. This bird was a yearling non-breeding male.
D. Birds 11 and 18 are not included.
E. The mean core area only includes the core areas with the nest.

TABLE 8. PREY IDENTIFIED AT *ACCIPITER* PLUCKS AND NESTS DURING 1984-88 IN THE JEMEZ MOUNTAINS, NM.

PREY TAXON	GOSHAWK	COOPER'S HAWK
BIRDS		
Northern Flicker	14 (26.4)	54 (22.0)
Stellar's Jay	9 (17.0)	37 (15.1)
Unid. Bird[B]	1 (1.9)	33 (13.5)
American Robin	7 (13.2)	28 (11.4)
Mourning Dove	0 (0.0)	21 (8.6)
Western Bluebird	1 (1.9)	9 (3.7)
Dark-eyed Junco	0 (0.0)	8 (3.3)
Scrub Jay	1 (1.9)	6 (2.4)
Rufous-sided Towhee	0 (0.0)	6 (2.4)
Unid. Jay	2 (3.8)	5 (2.0)
Common Raven	3 (5.7)	0 (0.0)
Clark's Nutcracker	3 (5.7)	3 (1.2)
American Kestrel	1 (1.9)	3 (1.2)
Cooper's Hawk	2 (3.8)	0 (0.0)
Prairie Falcon	1 (1.9)	0 (0.0)
Pygmy Owl	1 (1.9)	0 (0.0)
Starling	0 (0.0)	3 (1.2)
Domestic Fowl	0 (0.0)	3 (1.2)
Mountain Bluebird	0 (0.0)	2 (0.8)
Unid. Columbiformes	0 (0.0)	2 (0.8)
Unid. Passerine	1 (1.9)	2 (0.8)
Band-tailed Pigeon	0 (0.0)	2 (0.8)
Rock Dove	1 (1.9)	0 (0.0)
Empidonax sp.	0 (0.0)	2 (0.8)
Unid. Charadriformes	0 (0.0)	1 (0.4)
Violet-green Swallow	0 (0.0)	1 (0.4)
Black-billed Magpie	0 (0.0)	1 (0.4)
Yellow-rumped Warbler	0 (0.0)	1 (0.4)
Red Crossbill	0 (0.0)	1 (0.4)
House Finch	0 (0.0)	1 (0.4)
Brown-headed Cowbird	0 (0.0)	1 (0.4)
Western Flycatcher	0 (0.0)	1 (0.4)
Yellow-bellied Sapsucker	0 (0.0)	1 (0.4)
Unid. Sapsucker	0 (0.0)	1 (0.4)
Unid. Warbler	0 (0.0)	1 (0.4)
Ash-throated Flycatcher	0 (0.0)	1 (0.4)
Western Tanager	0 (0.0)	1 (0.4)
Pygmy Nuthatch	0 (0.0)	1 (0.4)
Unid. Sparrow	1 (1.9)	1 (0.4)
Unid. Bluebird	0 (0.0)	1 (0.4)
Belted Kingfisher	2 (3.8)	0 (0.0)
Evening Grosbeak	1 (1.9)	0 (0.0)
Hermit Thrush	1 (1.9)	0 (0.0)
TOTAL	53 (100.3)	245 (99.6)

TABLE 8 Continued

MAMMALS		
Eutamias sp.	2 (3.9)	25 (42.4)
Sylvilagus sp.	21 (41.2)	18 (30.5)
Sciurus aberti	10 (19.6)	5 (8.5)
Neotoma sp.	0 (0.0)	3 (5.1)
Tamiasciurus hudsonicus	3 (5.9)	2 (3.4)
Spermophilus lateralis	2 (3.9)	1 (1.7)
Spermophilus varigatus	0 (0.0)	1 (1.7)
Felis sp.	1 (2.0)	0 (0.0)
Unid. Cricetidae	0 (0.0)	1 (1.7)
Unid. Squirrel	7 (13.7)	1 (1.7)
Unid. Microtine	0 (0.0)	1 (1.7)
Unid. Mammal	21 (41.2)	18 (30.5)
TOTAL	51 (100.0)	59 (100.1)
REPTILE		
Cnemidophorus inornatus	0 (0.0)	2 (50.0)
Sceloporus undulatus	0 (0.0)	1 (25.0)
Thamnophis elegans	0 (0.0)	1 (25.0)
TOTAL	0 (0.0)	4 (100.0)
% Birds in Diet	51.0	79.5
% Mammals in Diet	49.0	19.2
% Reptiles in Diet	0.0	1.3

A. Minimum number of individuals. Numbers in parentheses are percent of total birds, mammals or reptiles.
B. The unidentified birds have been sent to the National US Fish and Wildlife Forensic Laboratory for identification.

TABLE 9. FREQUENCY OF OCCURRENCE OF *ACCIPITER* PREY IN EGESTED PELLETS COLLECTED IN THE JEMEZ MOUNTAINS, NM.

PREY TAXON	GOSHAWK (N=63)		COOPER'S HAWK (N=150)	
	N	%	N	%
MAMMALS				
Eutamias sp.	8	(12.7)	84	(56.0)
Sylvilagus sp.	4	(6.3)	10	(6.7)
Sciurus aberti	26	(41.3)	25	(16.7)
Tamiasciurus hudsonicus	11	(17.5)	14	(9.3)
Spermophilus lateralis	11	(17.5)	15	(10.0)
Spermophilus varigatus	3	(4.8)	1	(0.7)
Peromyscus maniculatus	0	(0.0)	1	(0.7)
Peromyscus sp.	0	(0.0)	1	(0.7)
Unid. Cricetidae	0	(0.0)	2	(1.3)
Unid. Tree Squirrel	3	(4.8)	0	(0.0)
Unid. Microtine	2	(3.2)	4	(2.7)
Unid. Rodent	4	(6.3)	3	(2.0)
Unid. Mammal	1	(1.6)	1	(0.7)
TOTAL MAMMALS	59	(93.7)	132	(88.0)
TOTAL BIRDS[A]	58	(92.1)	118	(78.7)
REPTILES				
Sceloporus undulatus	0	(0.0)	10	(6.7)
Sceloporus sp.	0	(0.0)	3	(2.0)
Cnemidophorus sp.	0	(0.0)	7	(4.7)
Cnemidophorus inornatus	0	(0.0)	2	(1.3)
Unid. reptile	0	(0.0)	5	(3.3)
TOTAL REPTILES	0	(0.0)	27	(18.0)

A. The feathers are being identified at the National Fish and Wildlife Forensic Laboratory.

FIGURE 1. COVER CLASS DISTRIBUTION OF LOS ALAMOS COUNTY. The County boundaries are indicated by the dotted line. The white areas are Cover Class 1; the yellow areas are Cover Class 2; the green areas are Cover Class 3; and the blue areas are Cover Class 4. The northern white portion of the map is the area that has not been digitized.

FIGURE 2. HARMONIC MEAN HOME RANGE ESTIMATES OF MALE GOSHAWK - 01, MATE OF BIRD 02.

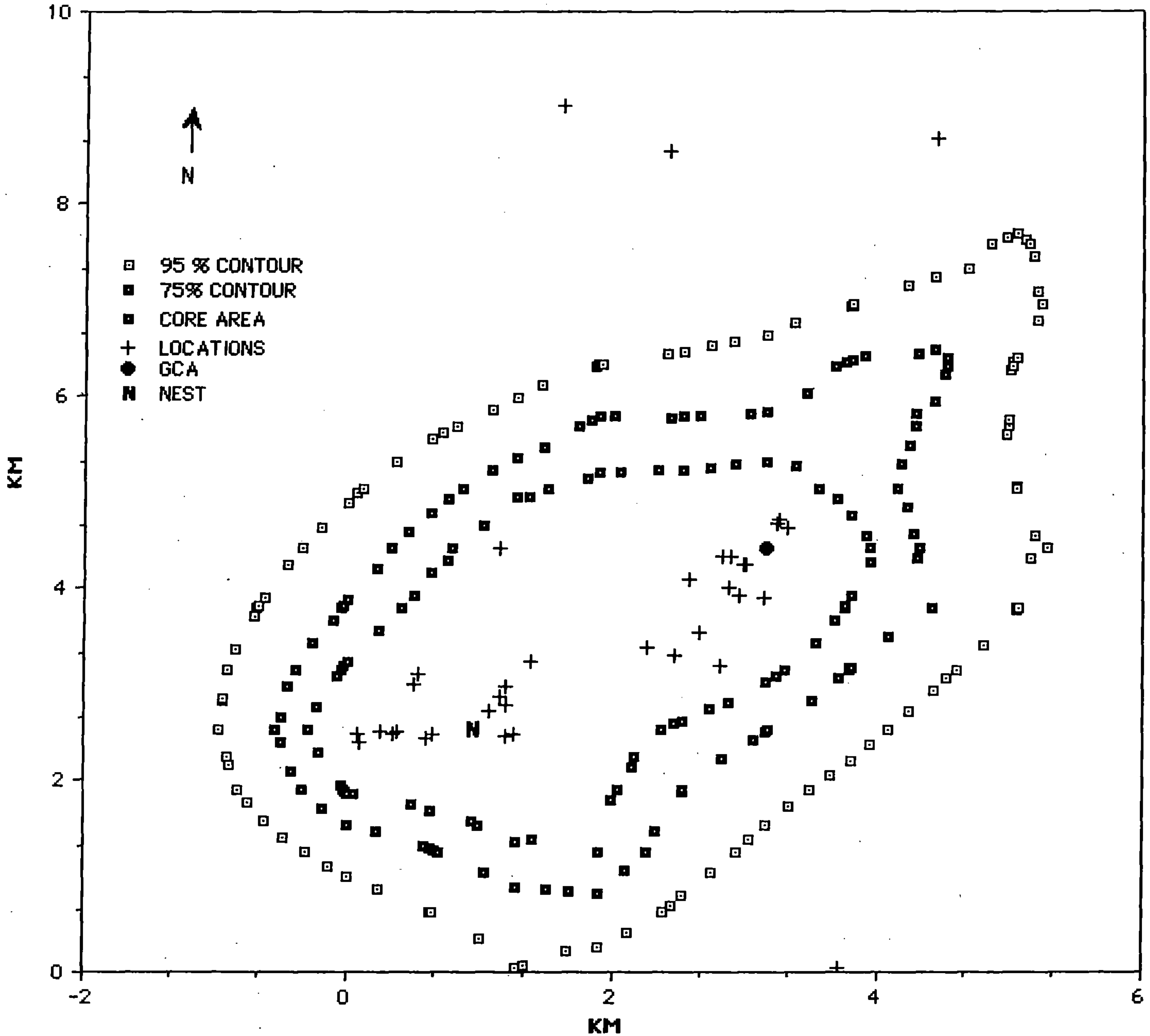

FIGURE 3. HARMONIC MEAN HOME RANGE ESTIMATES OF FEMALE GOSHAWK 02, MATE OF BIRD 01.

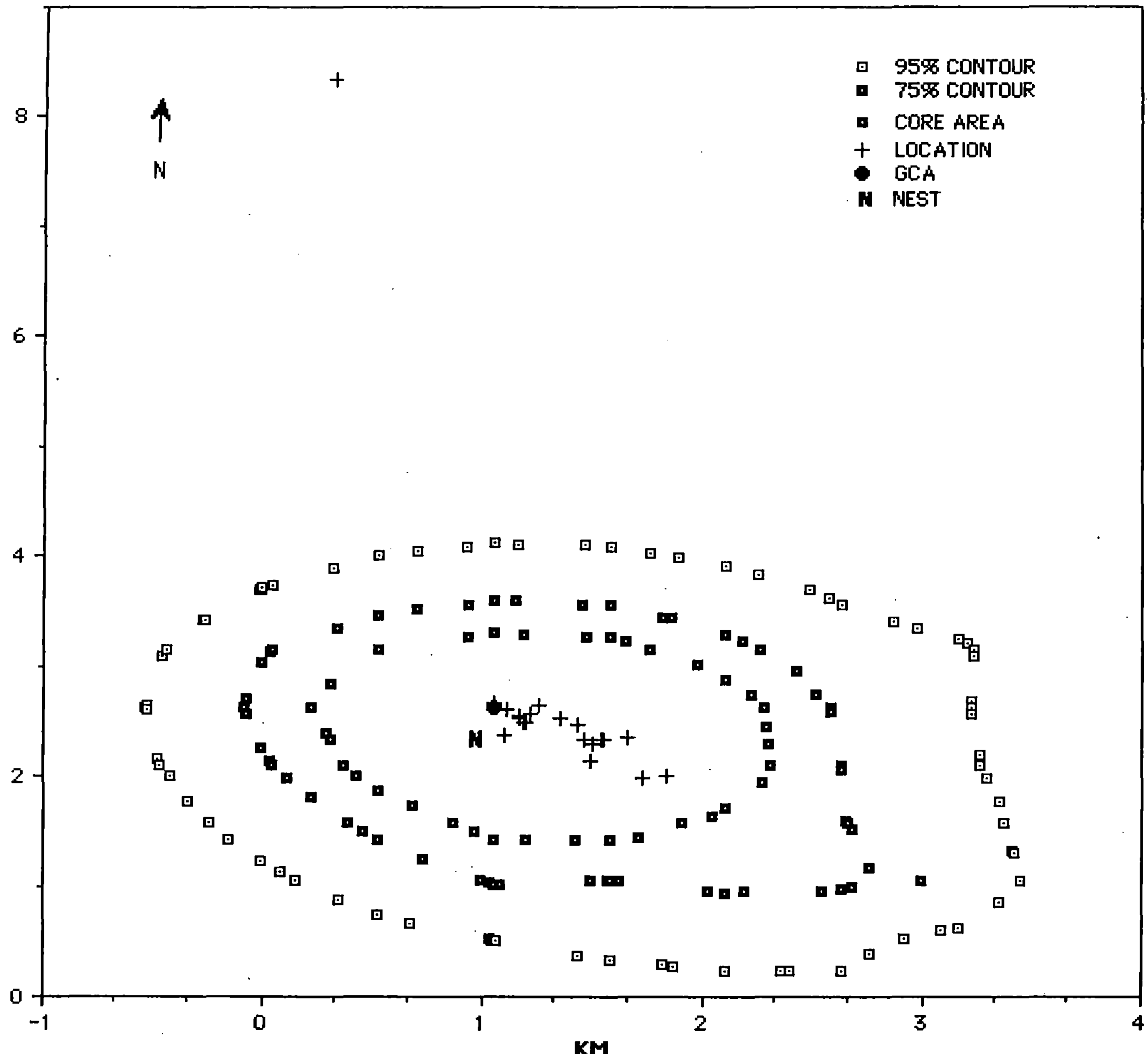

FIGURE 5. HARMONIC MEAN HOME RANGE ESTIMATES OF FEMALE COOPER'S HAWK - 04.

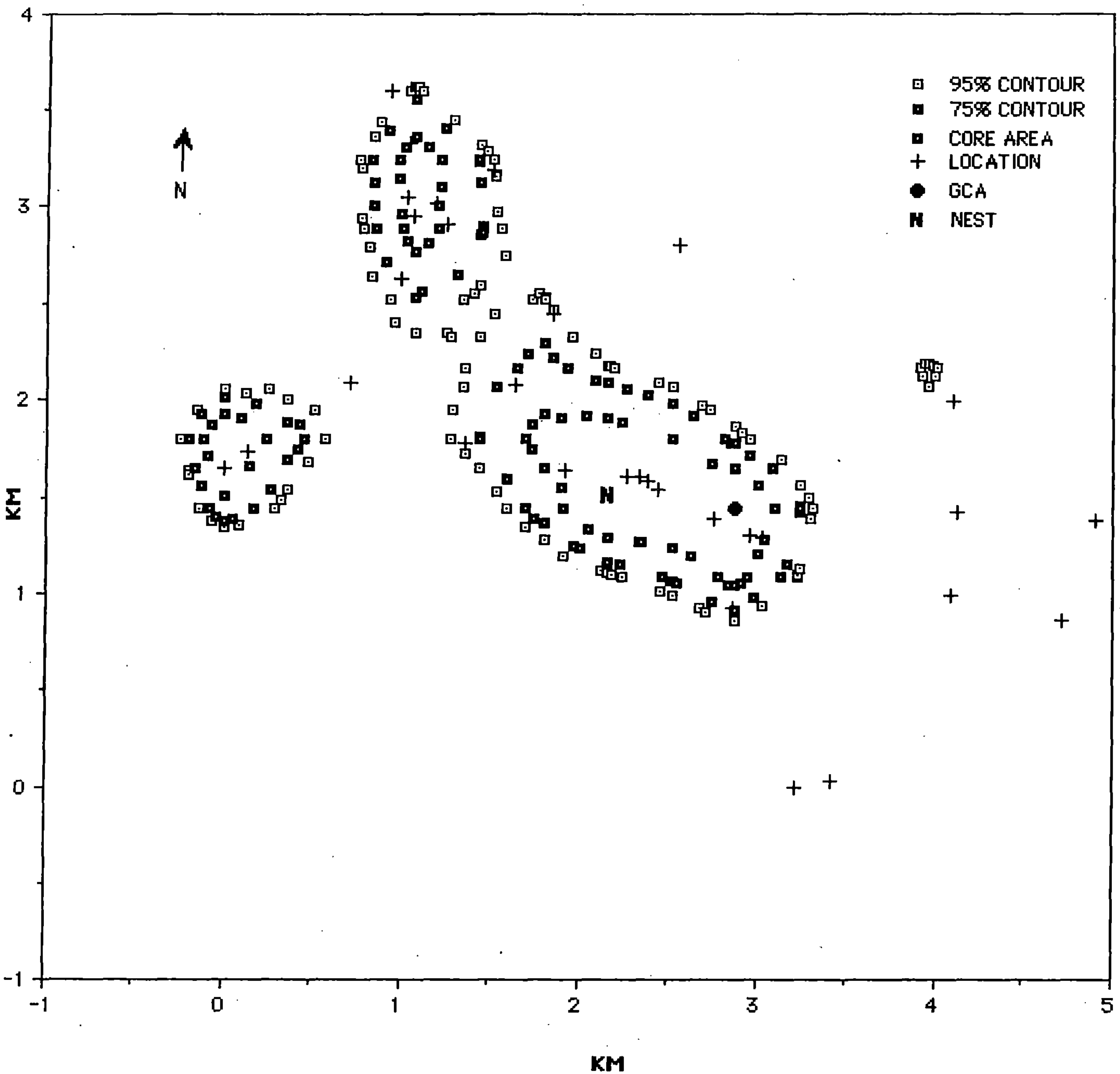

FIGURE 6. HARMONIC MEAN HOME RANGE ESTIMATES OF FEMALE COOPER'S HAWK - 05, MATE OF BIRD 06.

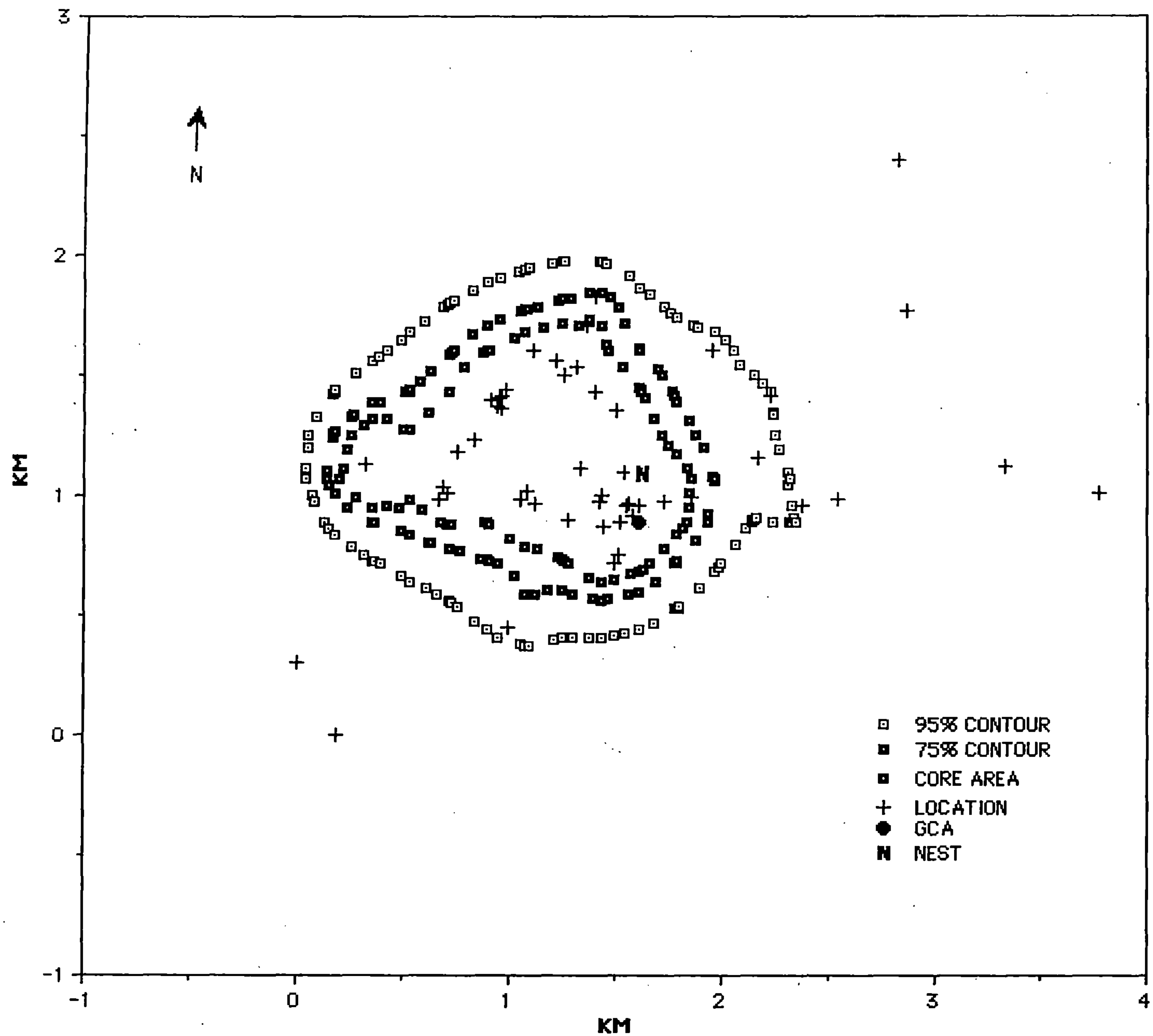

FIGURE 7. HARMONIC MEAN HOME RANGE ESTIMATES OF MALE COOPER'S HAWK 06, MATE OF BIRD 05.

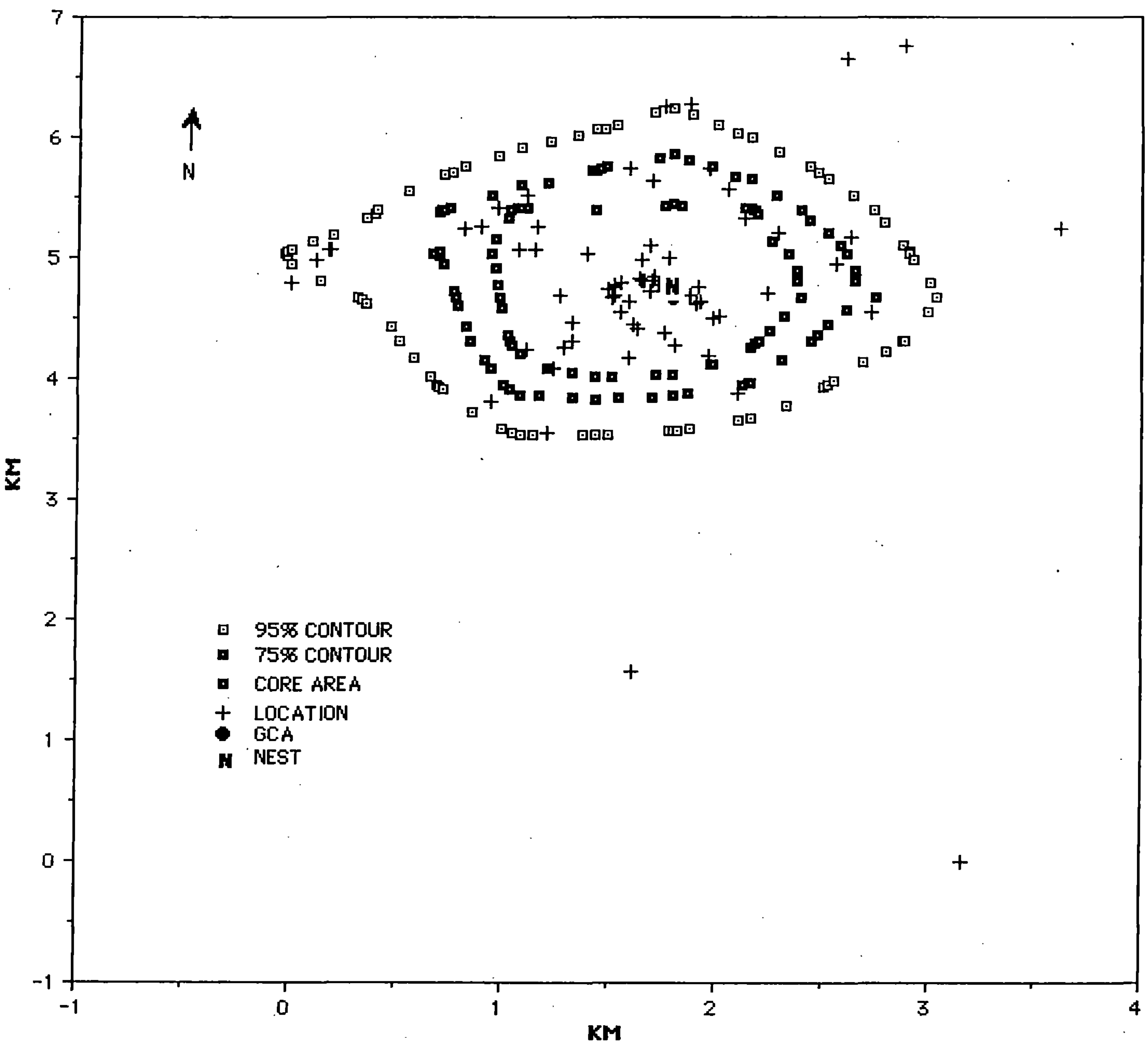

FIGURE 8. HARMONIC HOME RANGE ESTIMATES OF FEMALE GOSHAWK - 07

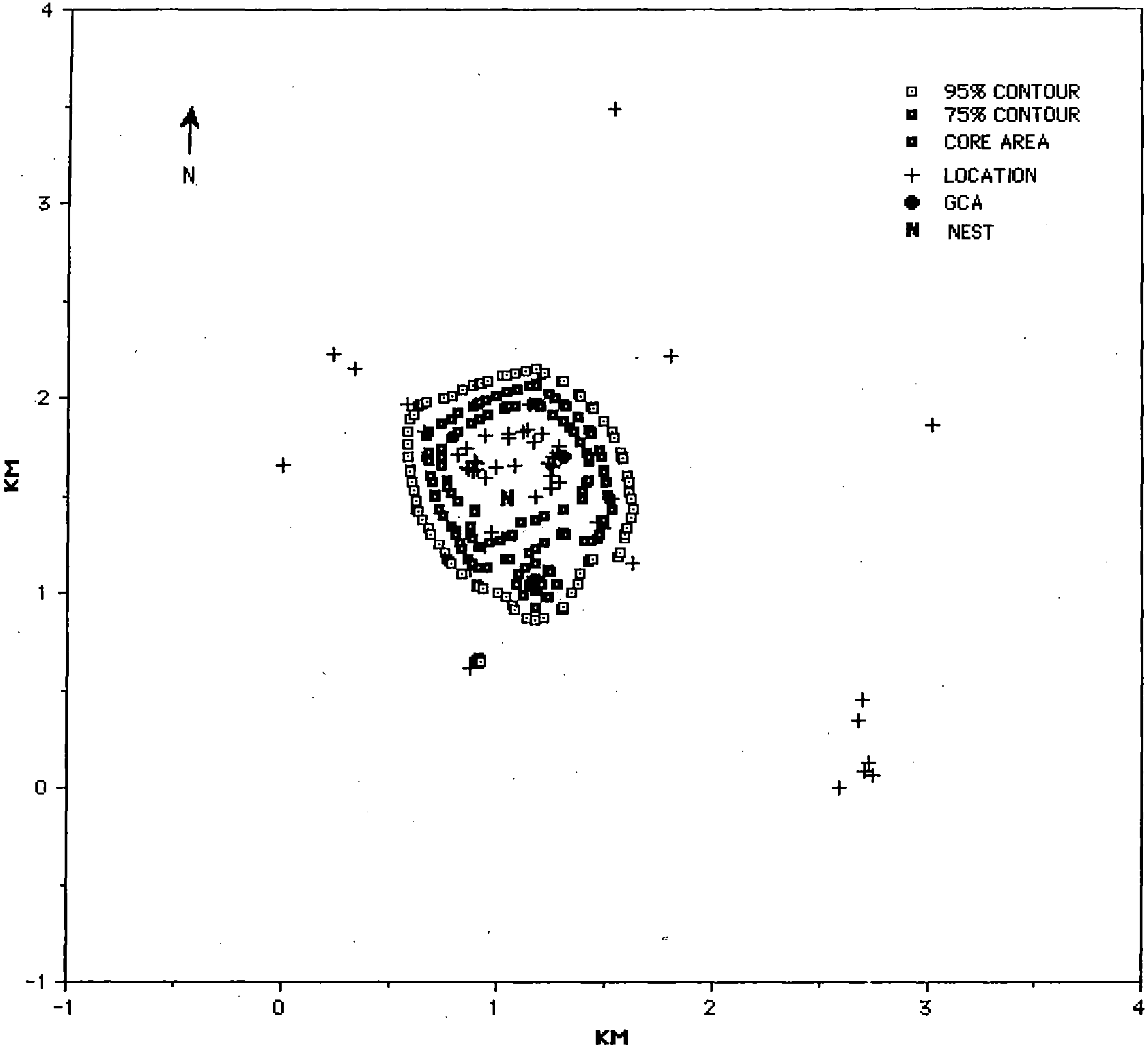

FIGURE 9. HARMONIC MEAN HOME RANGE ESTIMATES OF MALE COOPER'S HAWK – 08, MATE OF BIRD 09.

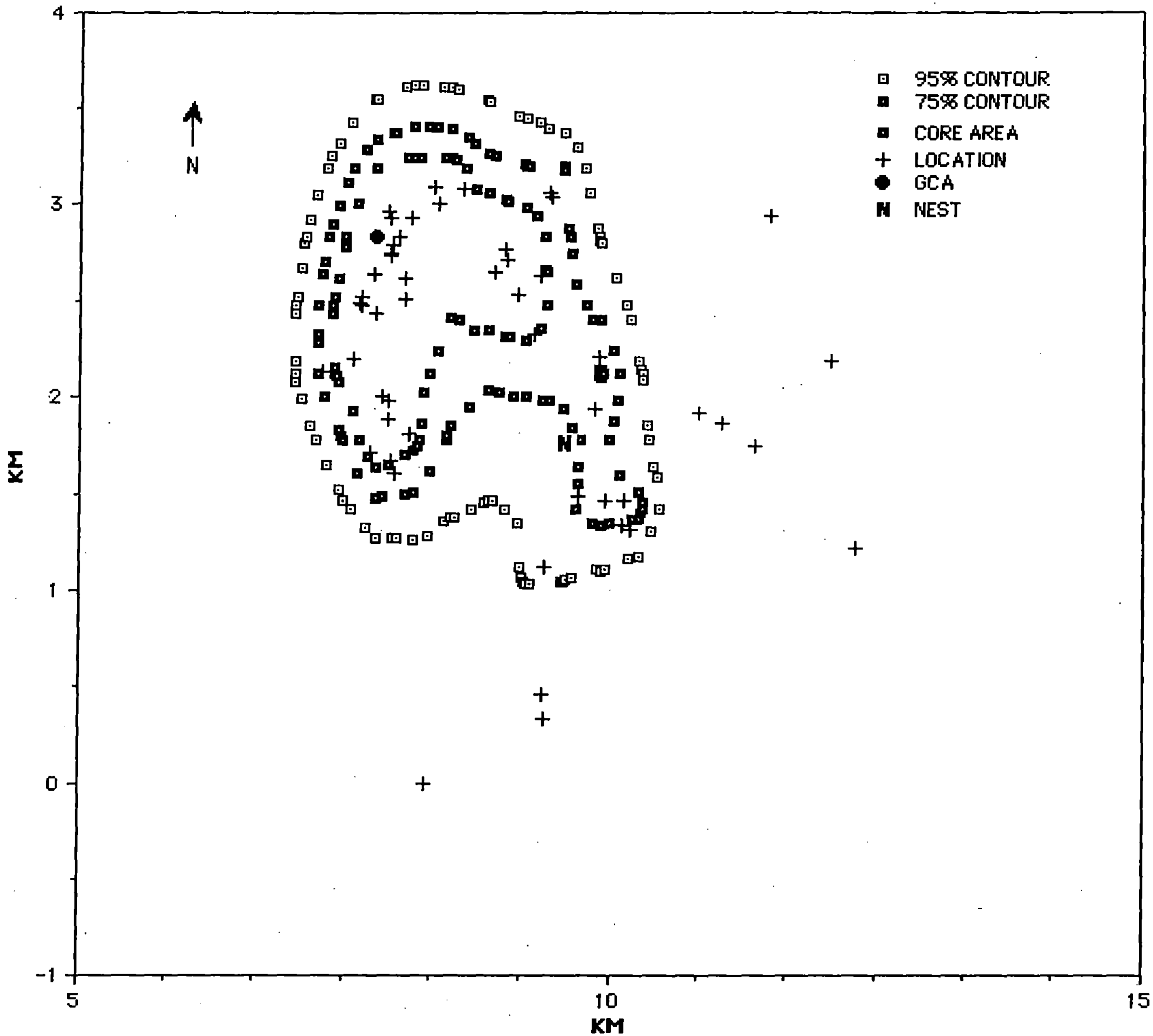

FIGURE 10. HARMONIC MEAN ESTIMATES OF FEMALE COOPER'S HAWK - 09, MATE OF BIRD 08.

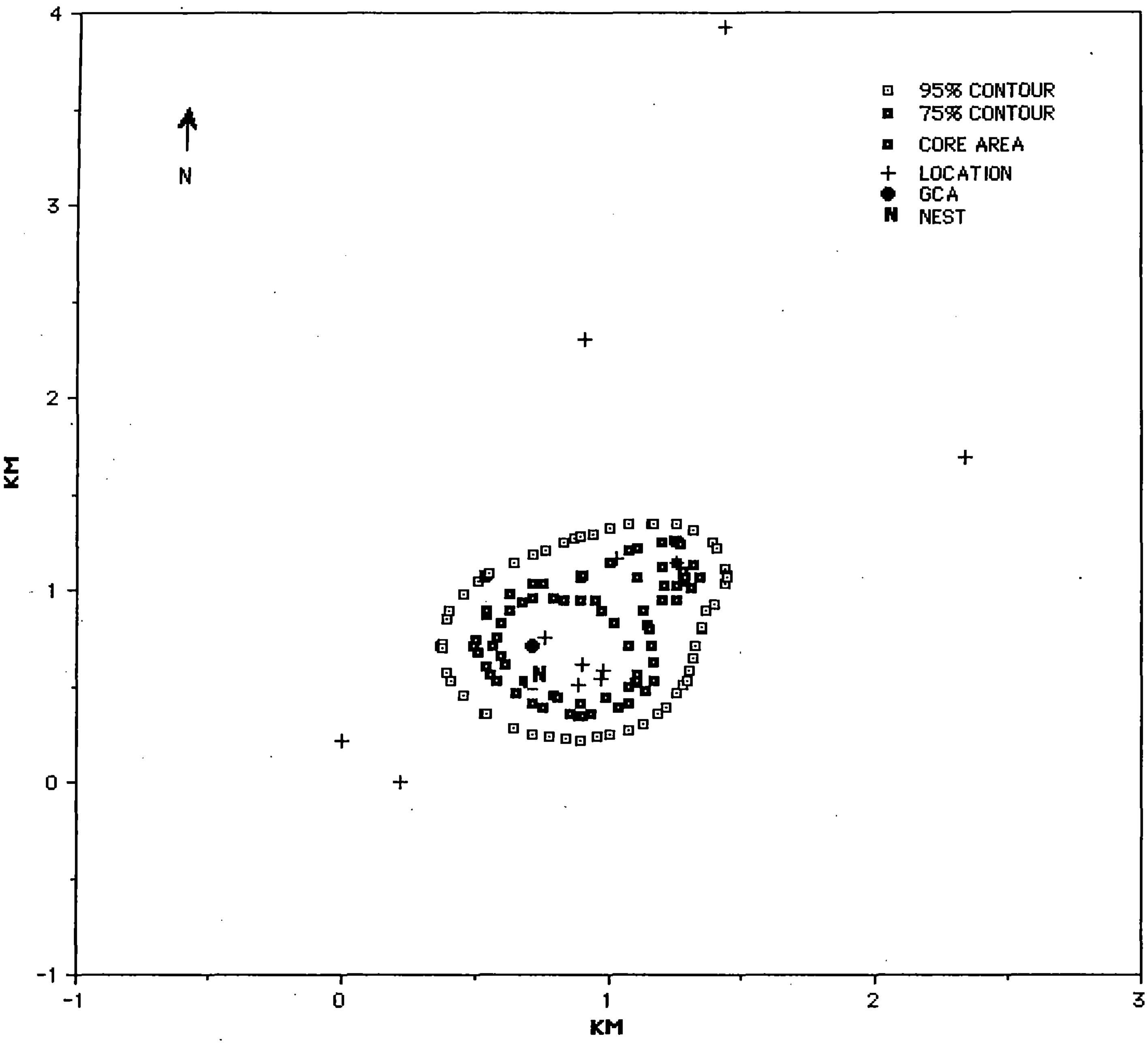

FIGURE 11. HARMONIC HOME RANGE ESTIMATES OF FEMALE COOPER'S HAWK - 10, MATE OF BIRD 11; 1986 DATA

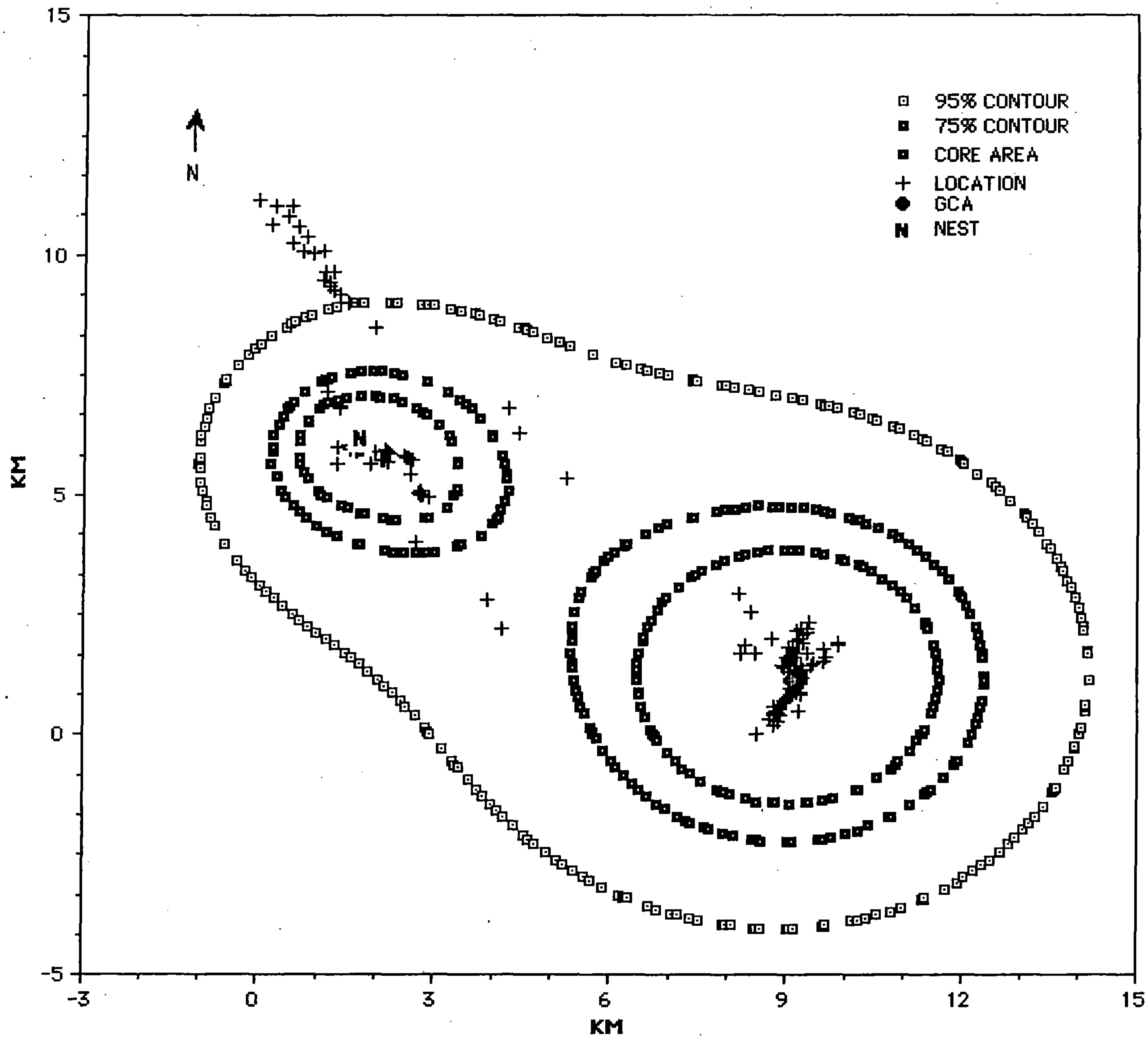

FIGURE 12. HARMONIC MEAN ESTIMATES HOME RANGE ESTIMATES OF FEMALE COOPER'S HAWK - 10; 1988 DATA

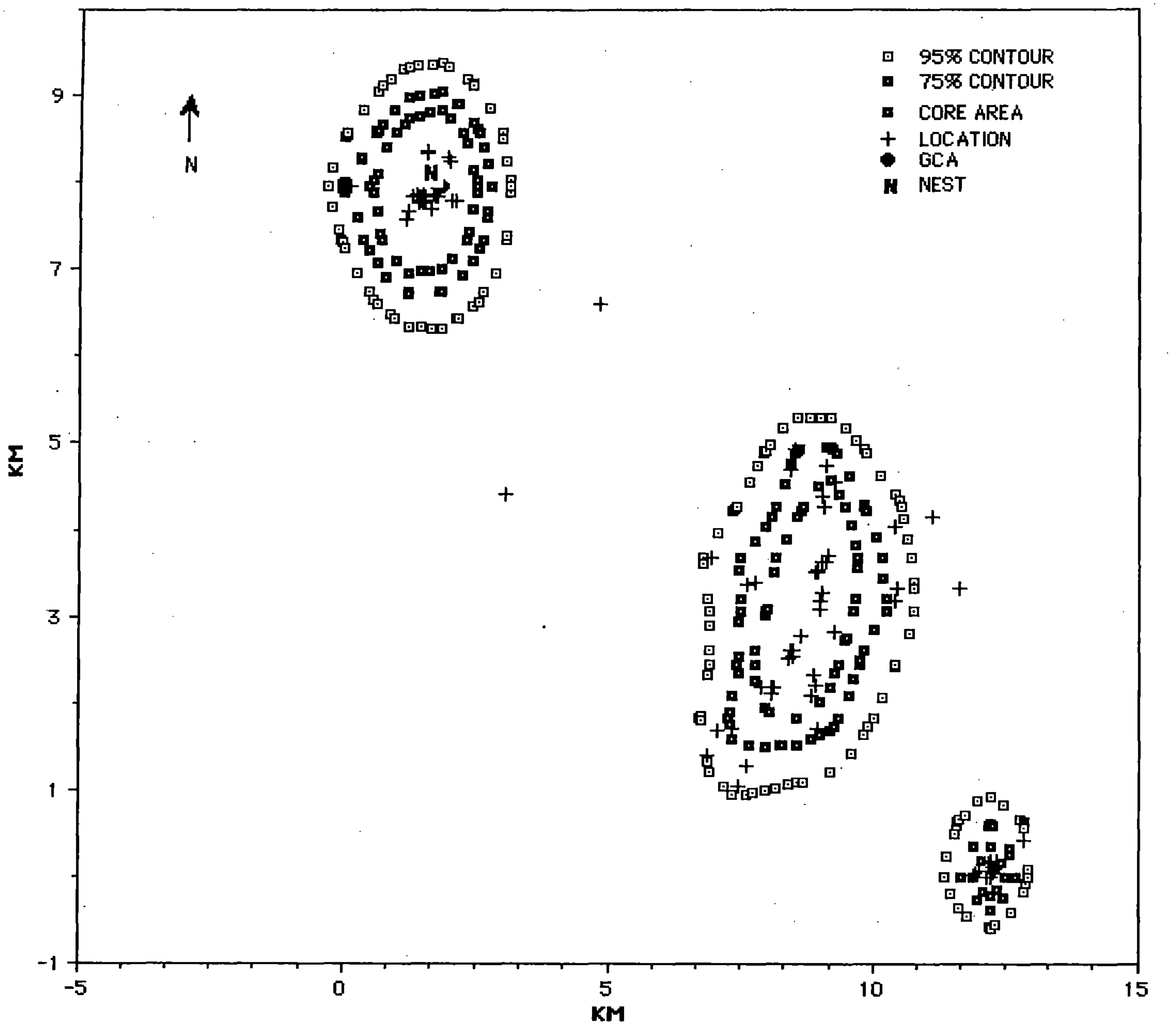

FIGURE 13. HARMONIC MEAN HOME RANGE ESTIMATES OF FEMALE COOPER'S HAWK - 12.

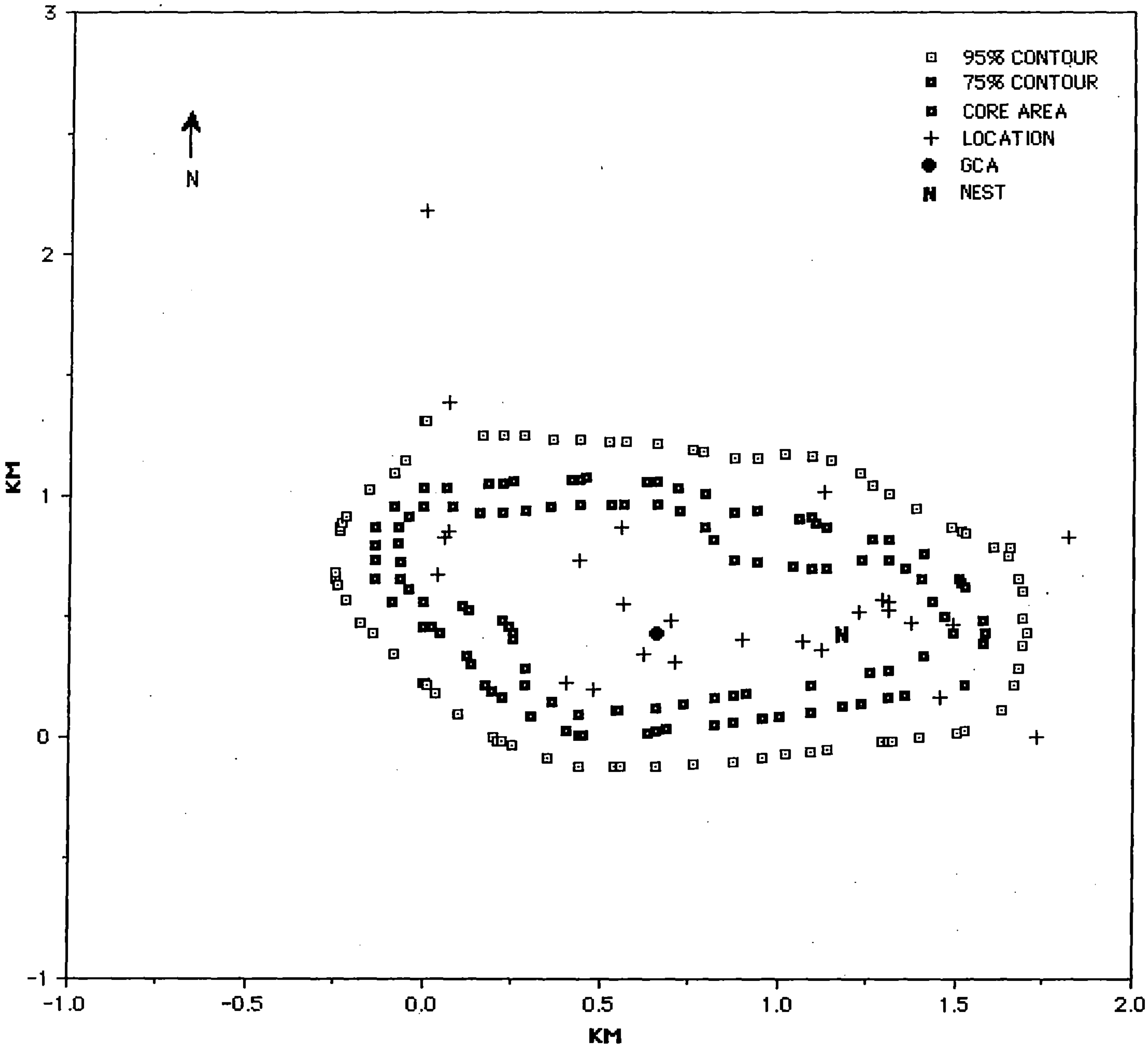

FIGURE 14. HARMONIC MEAN ESTIMATES OF FEMALE COOPER'S HAWK 13; MATE OF BIRD 14.

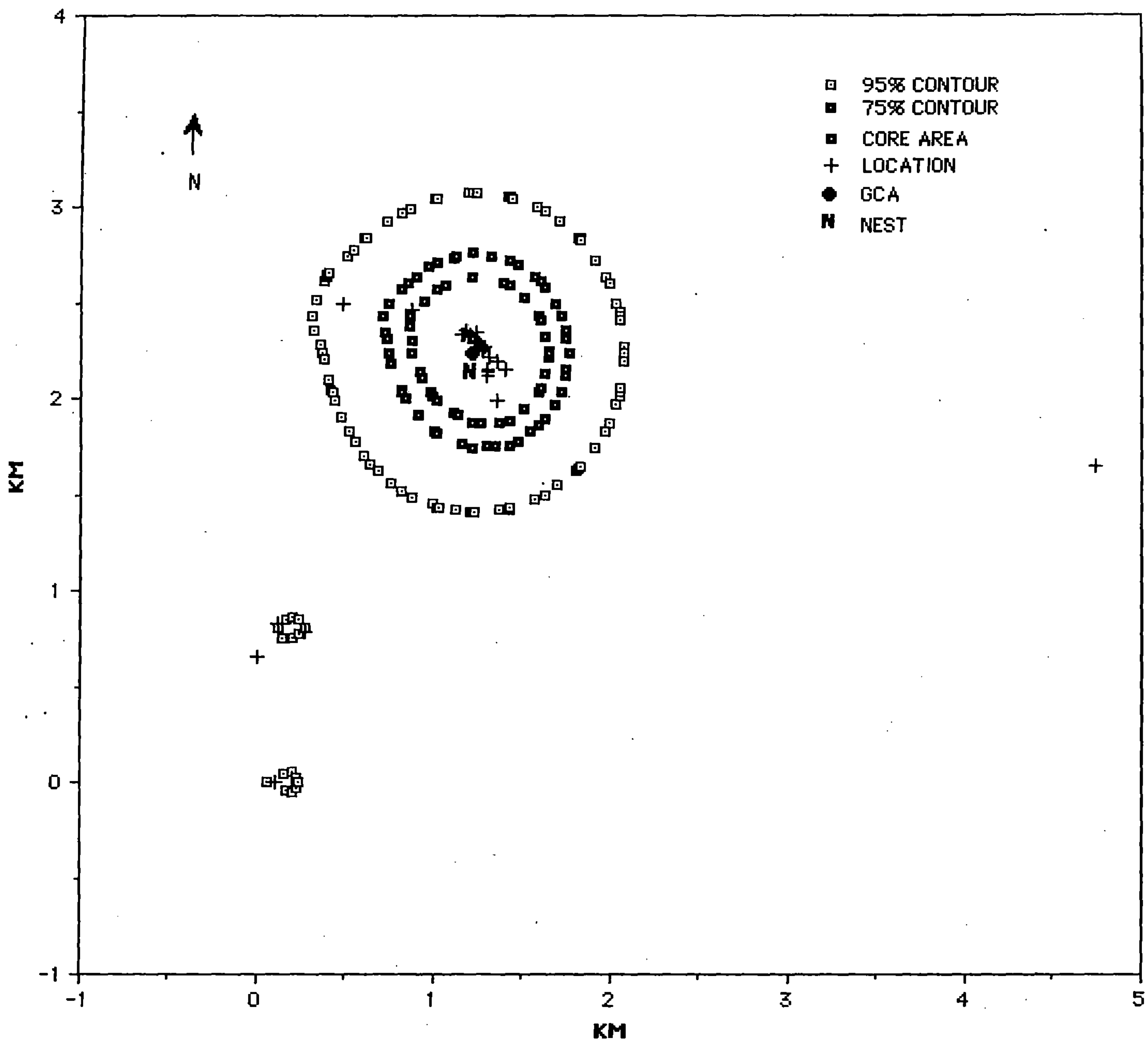

FIGURE 15. HARMONIC MEAN HOME RANGE ESTIMATES OF MALE COOPER'S HAWK - 14; MATE OF BIRD 13.

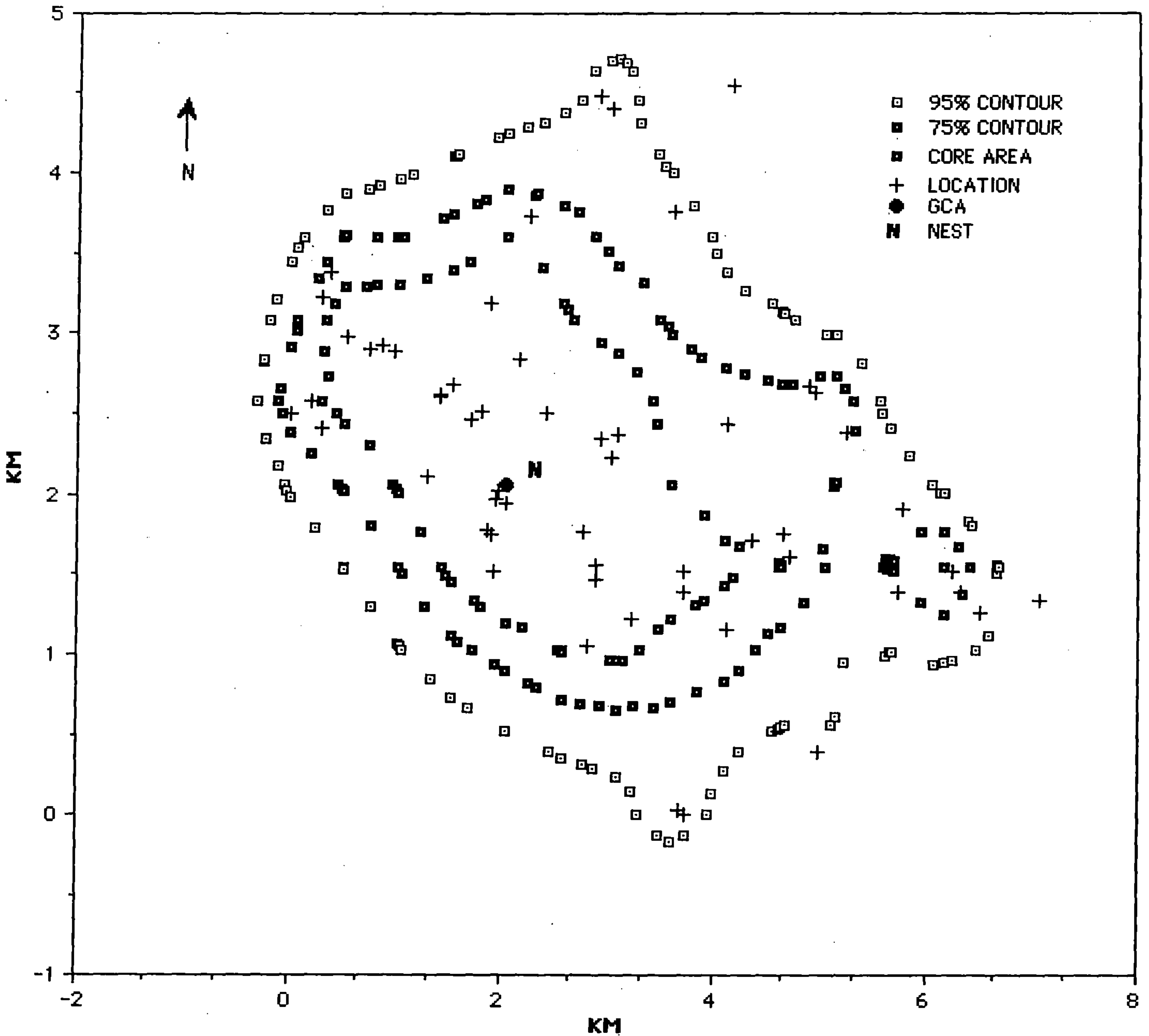

FIGURE 16. HARMONIC MEAN HOME RANGE ESTIMATES OF MALE COOPER'S HAWK - 15.

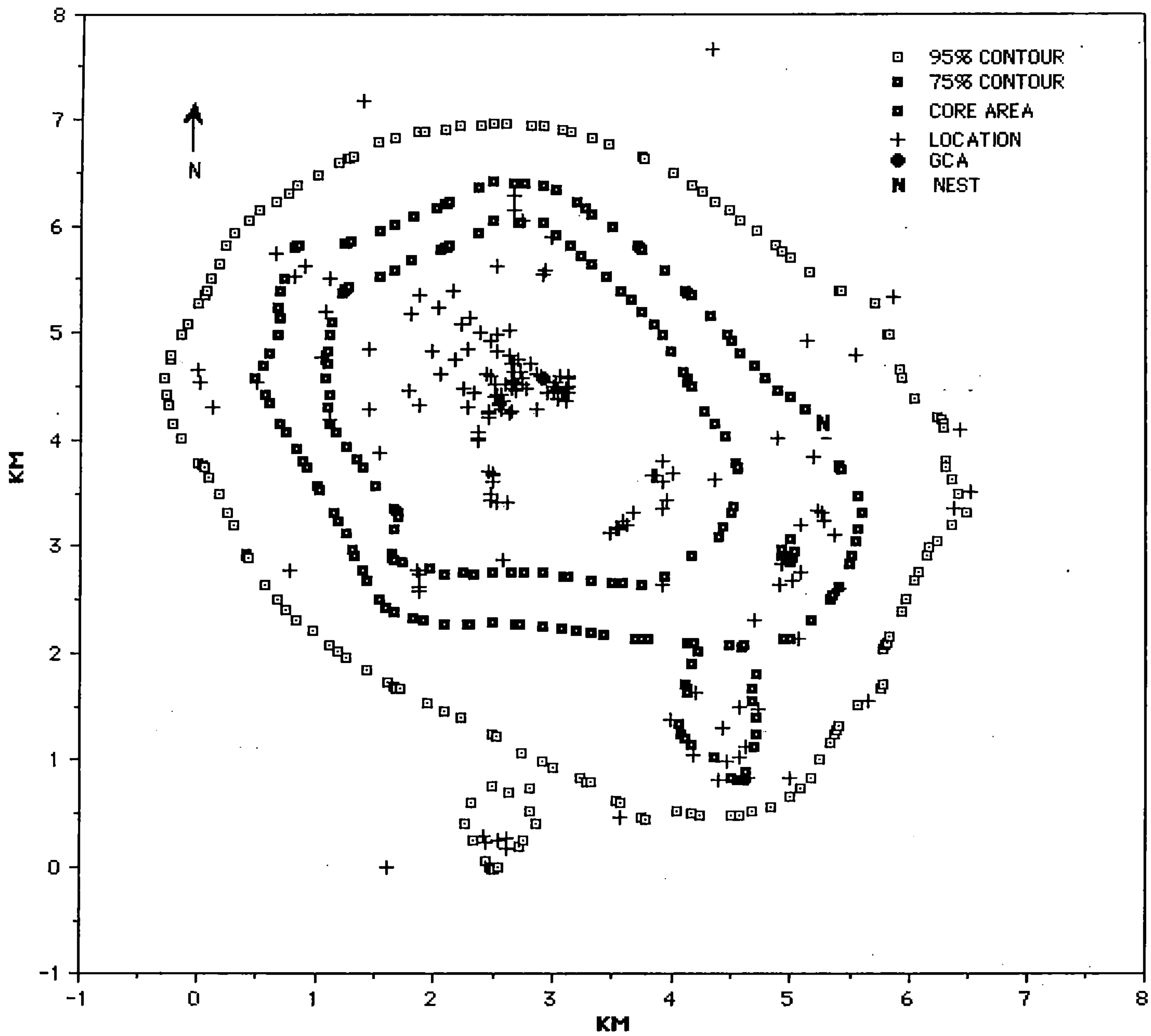

FIGURE 17. HARMONIC MEAN HOME RANGE ESTIMATES OF FEMALE COOPER'S HAWK - 16; MATE OF BIRD 17.

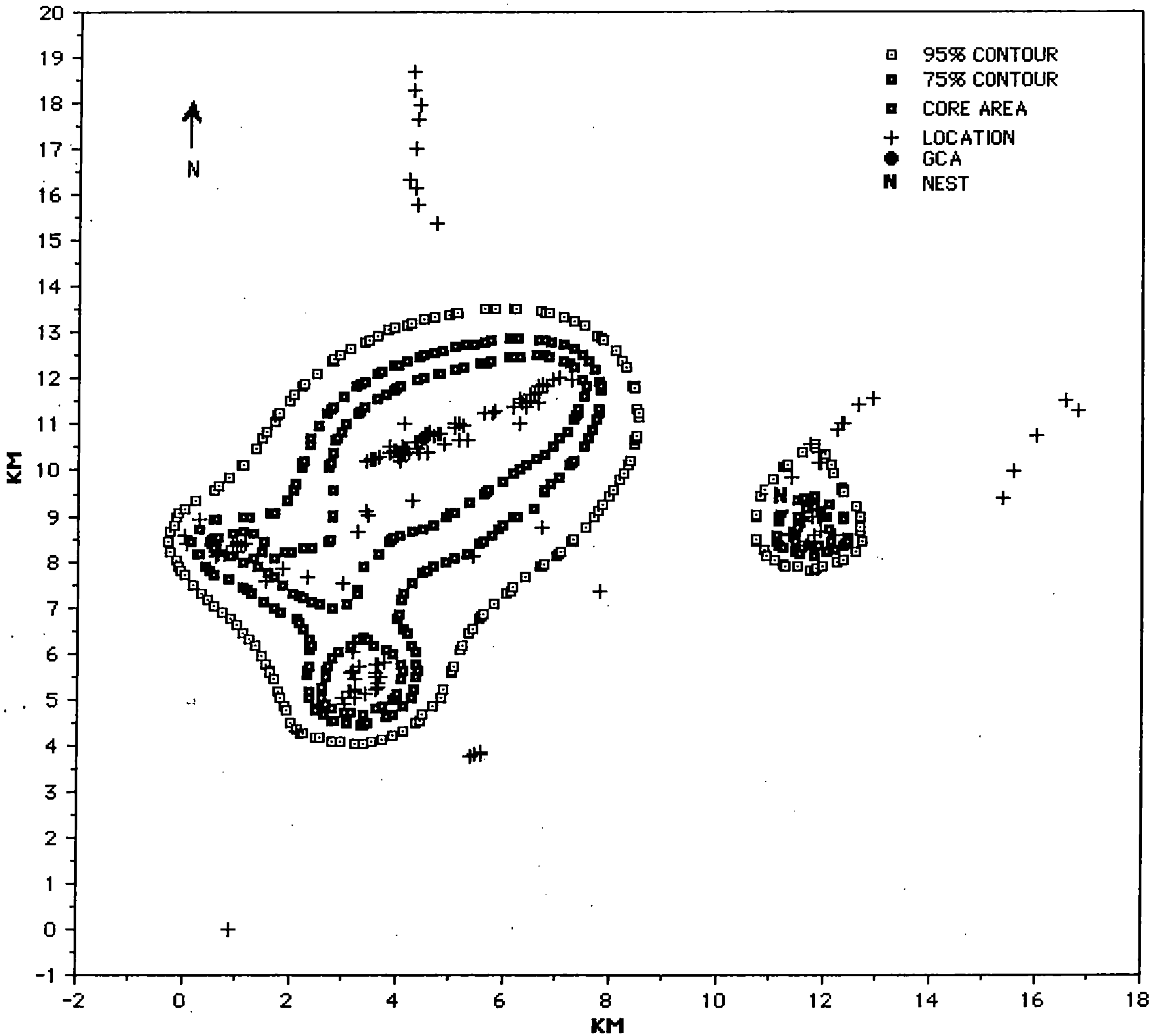

FIGURE 18. HARMONIC MEAN HOME RANGE ESTIMATES OF MALE COOPER'S HAWK - 17; MATE OF BIRD 16

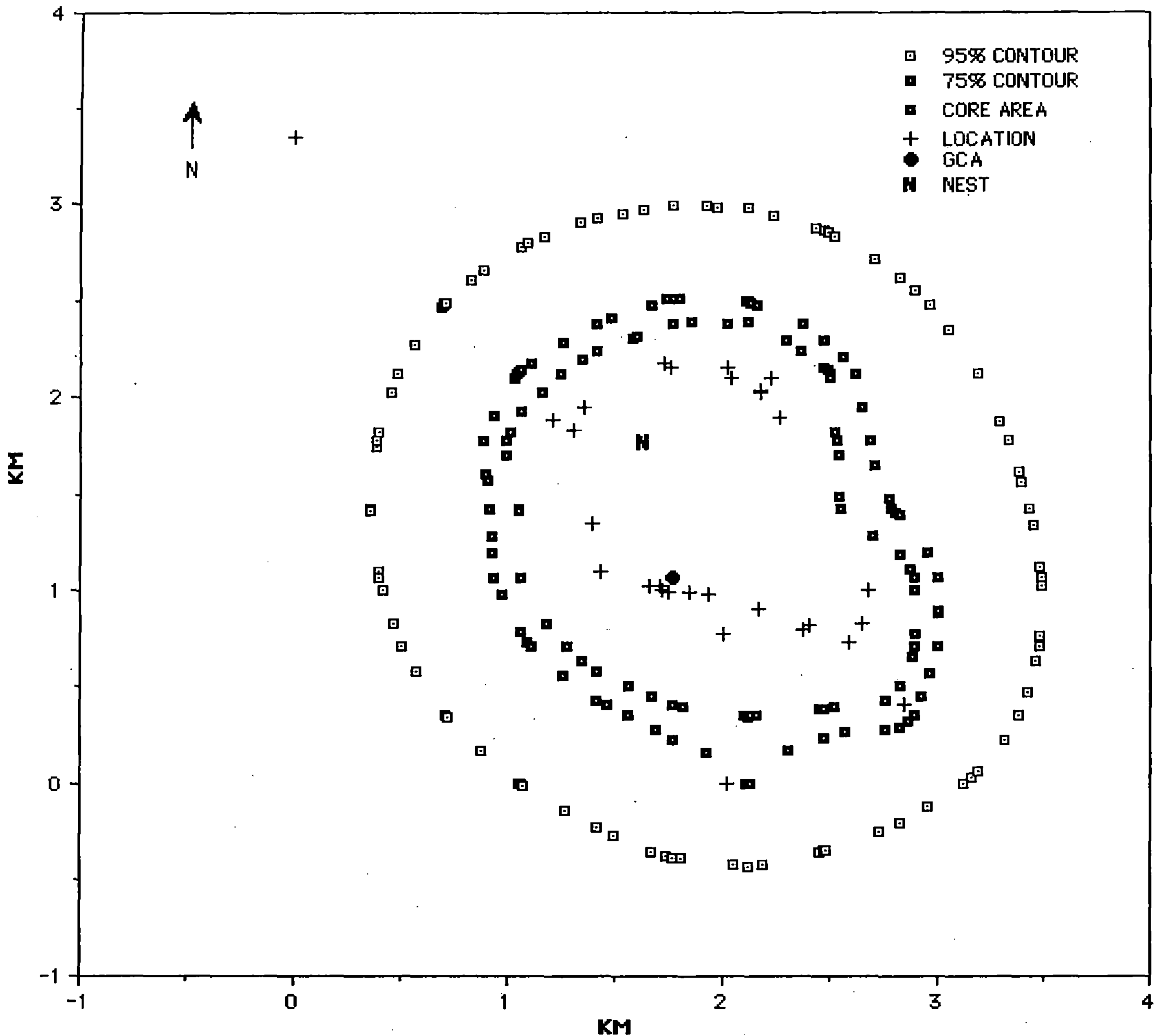

FIGURE 19. HARMONIC MEAN HOME RANGE ESTIMATES OF MALE COOPER'S HAWK - 18, A NON-BREEDING YEARLING.

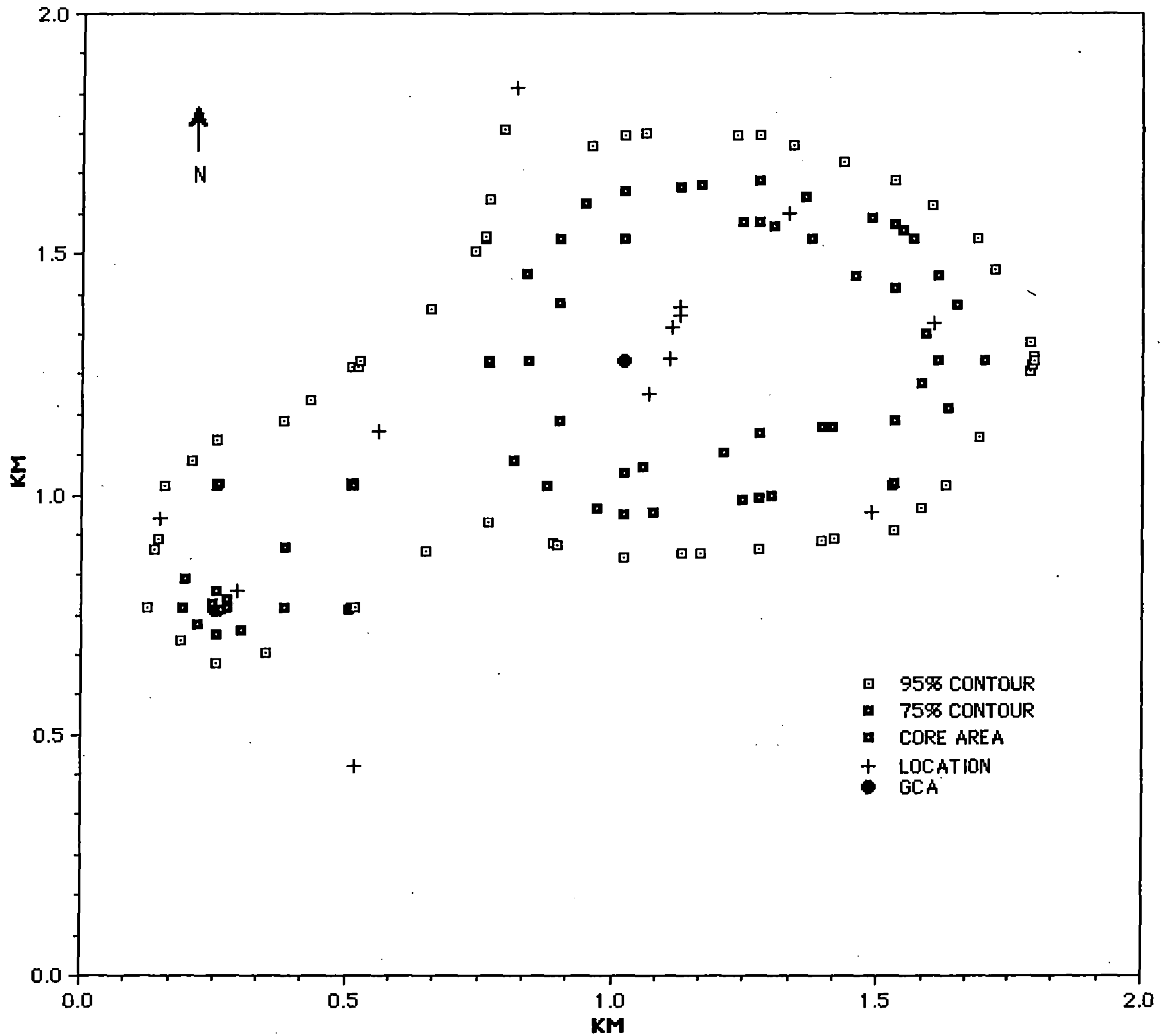

FIGURE 20. HARMONIC MEAN HOME RANGE ESTIMATES OF FEMALE GOSHAWK - 19.

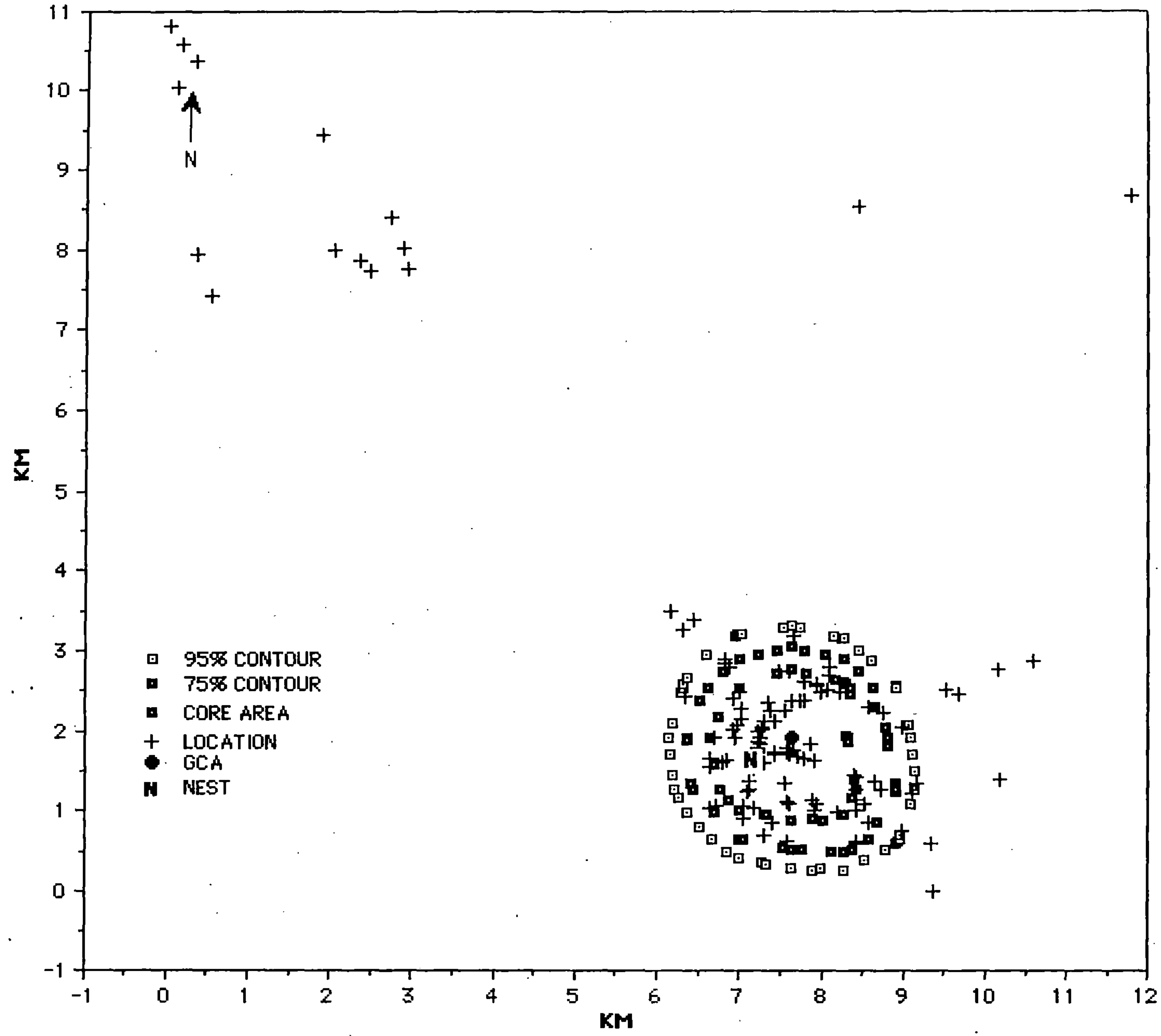

FIGURE 21. HARMONIC MEAN HOME RANGE ESTIMATES OF MALE COOPER'S HAWK - 21.

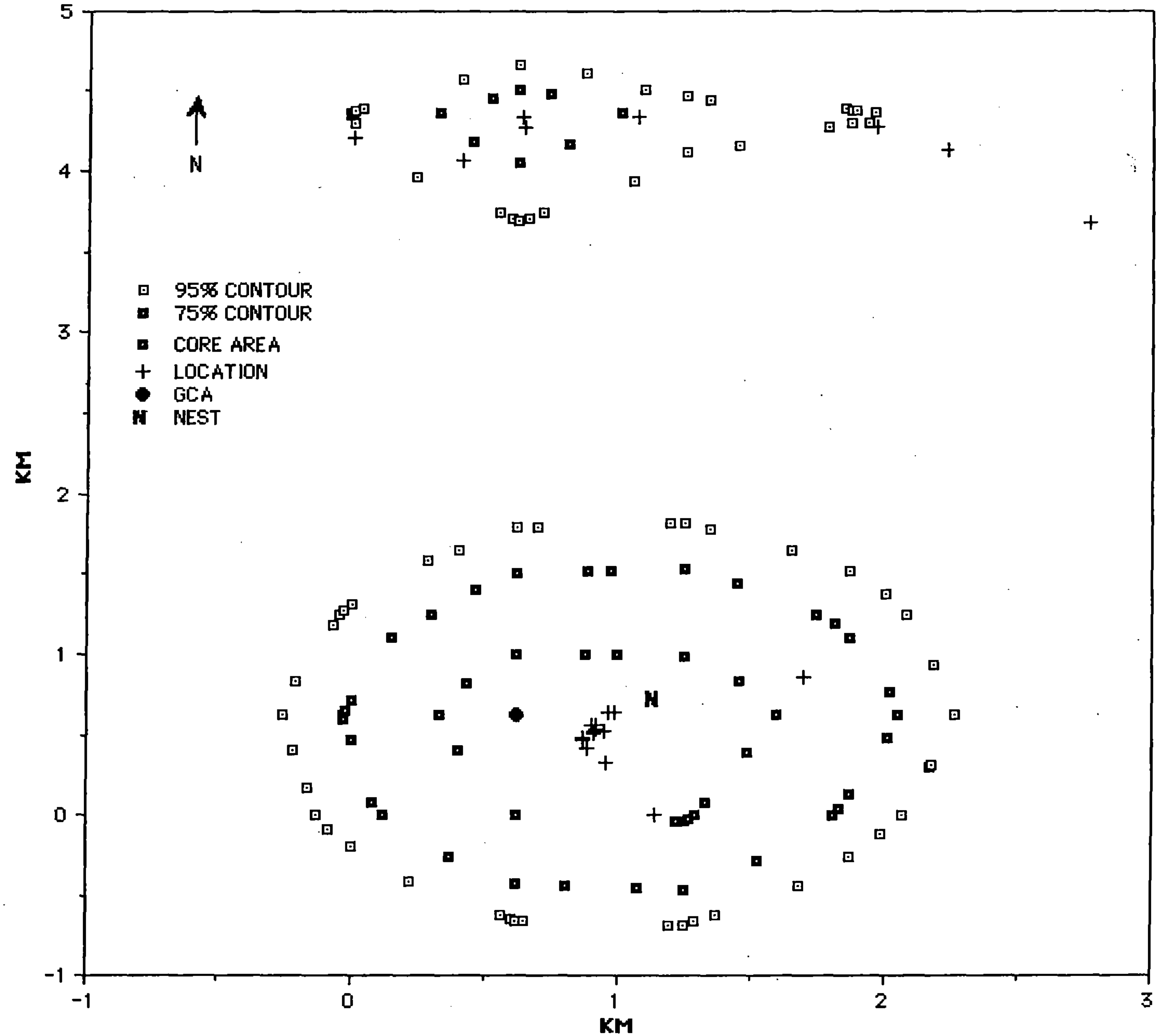

FIGURE 22. HARMONIC MEAN HOME RANGE ESTIMATES OF MALE GOSHAWK - 22.

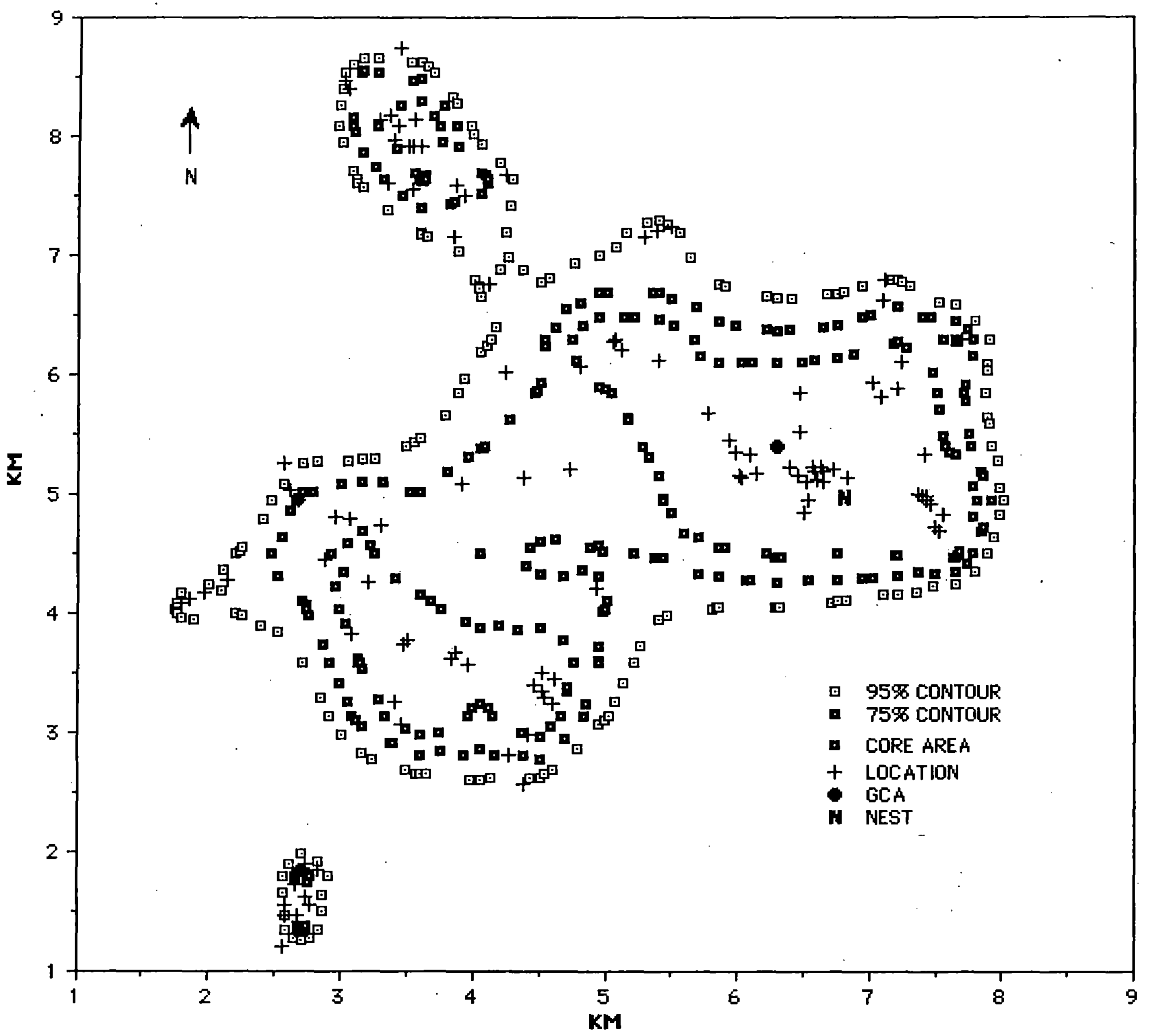

FIGURE 23. HARMONIC MEAN HOME RANGE ESTIMATES OF MALE COOPER'S HAWK - 23.

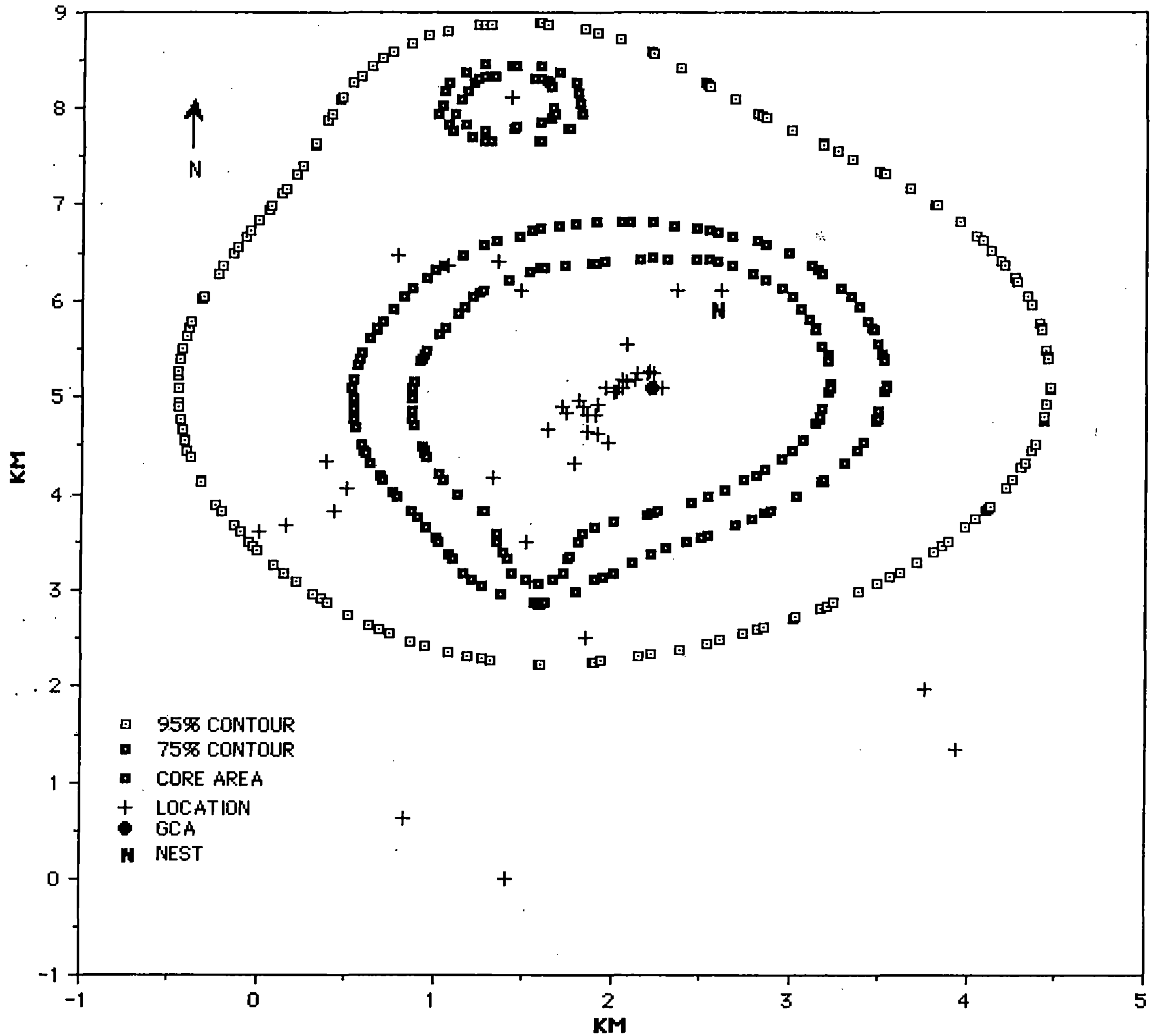

FIGURE 24. HARMONIC MEAN HOME RANGE ESTIMATES OF MALE COOPER'S HAWK - 25; MATE OF BIRD 26.

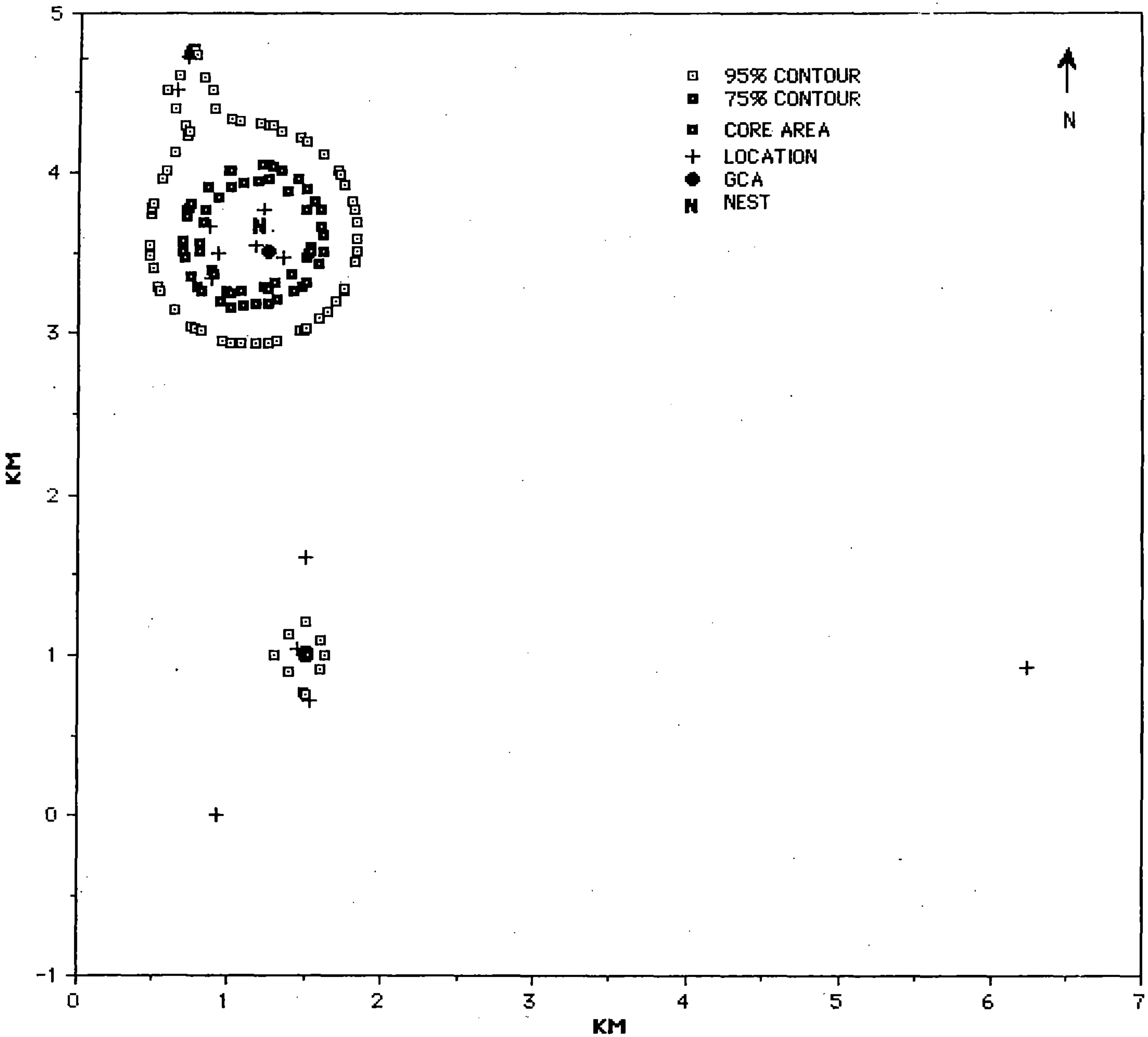

FIGURE 25. HARMONIC MEAN HOME RANGE ESTIMATES OF FEMALE COOPER'S HAWK - 26; MATE OF BIRD 25.

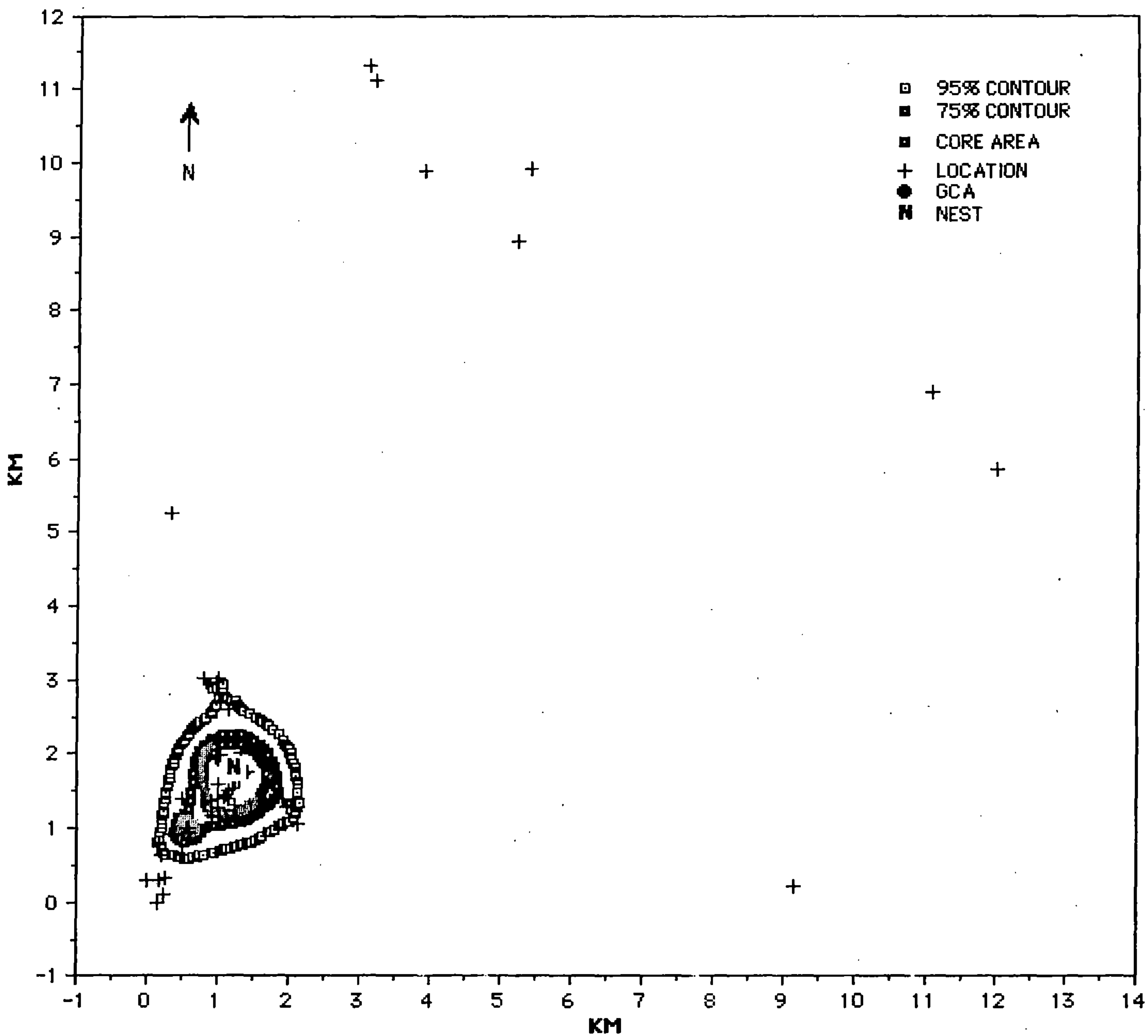

FIGURE 26. HARMONIC MEAN HOME RANGE ESTIMATES OF MALE GOSHAWK - 27, MATE OF BIRD 28.

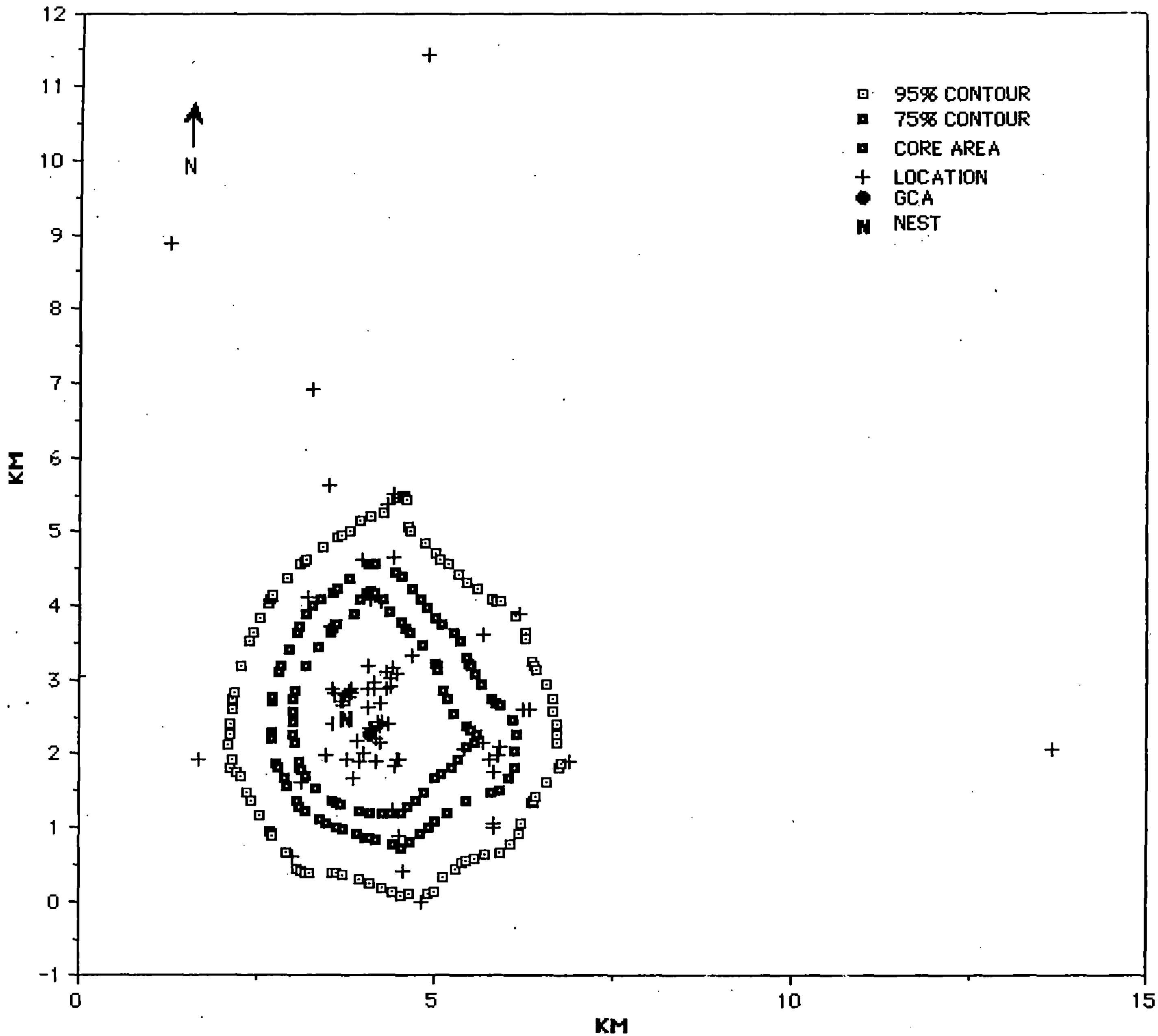

FIGURE 27. HARMONIC MEAN HOME RANGE ESTIMATES OF FEMALE GOSHAWK – 28 – NESTING SEASON 1988; MATE OF BIRD 27.

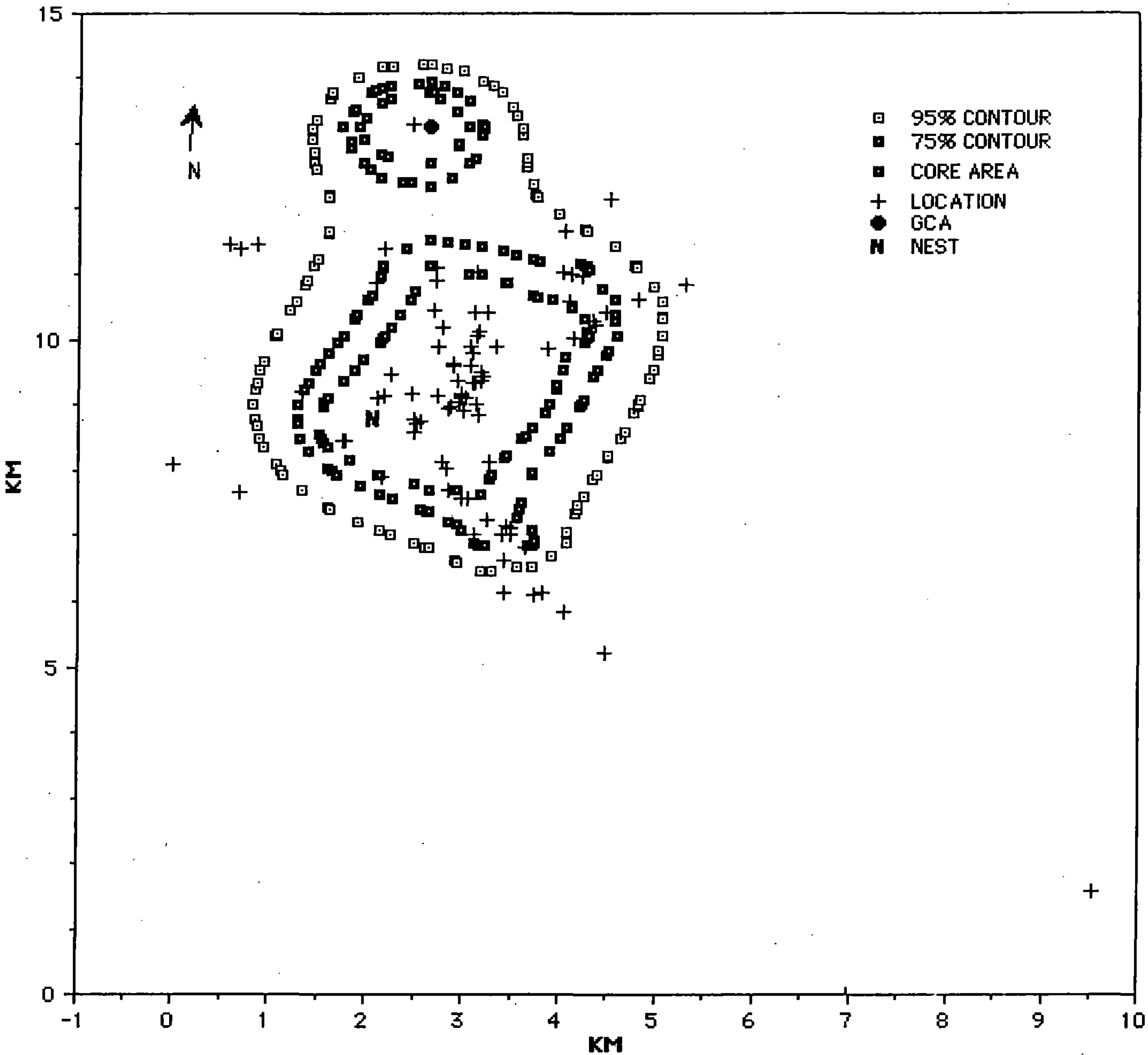

FIGURE 28. HARMONIC MEAN HOME RANGE ESTIMATES OF FEMALE GOSHAWK - 28 WINTER 1988-89.

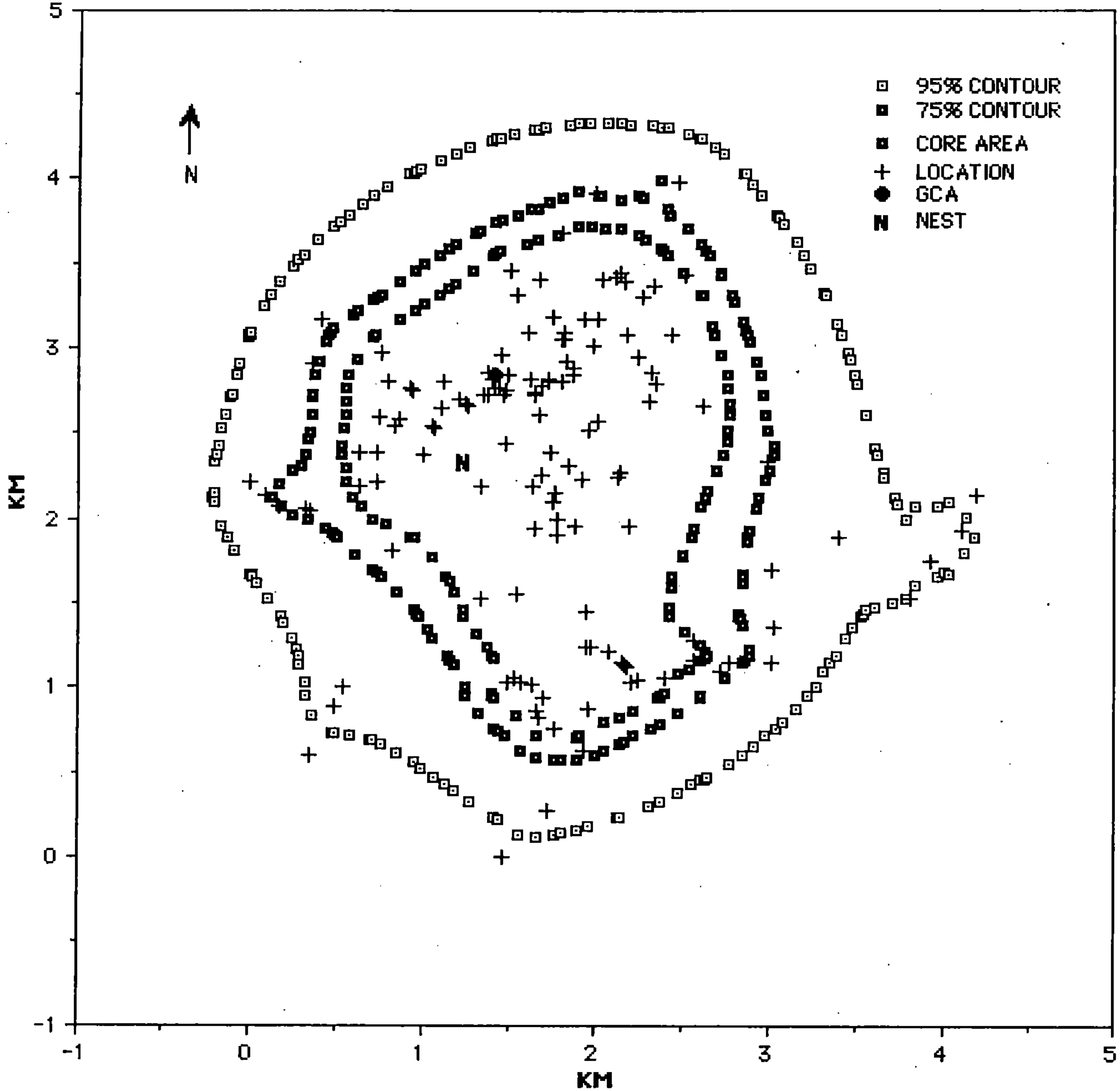

FIGURE 29. HARMONIC MEAN HOME RANGE ESTIMATES OF FEMALE COOPER'S HAWK - 29.

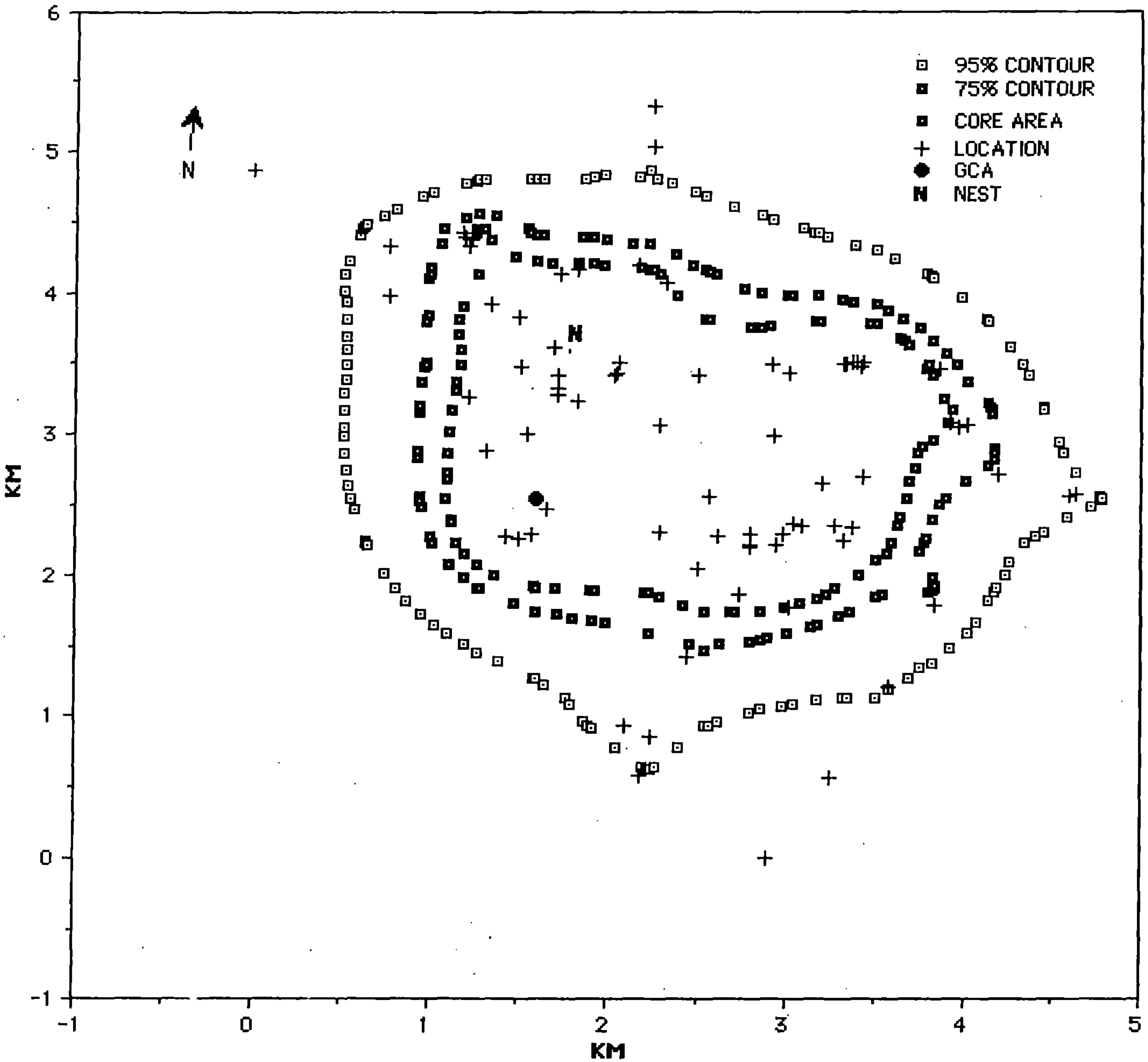

FIGURE 30. HARMONIC MEAN HOME RANGE ESTIMATES OF FEMALE COOPER'S HAWK - 30; MATE OF BIRD 32.

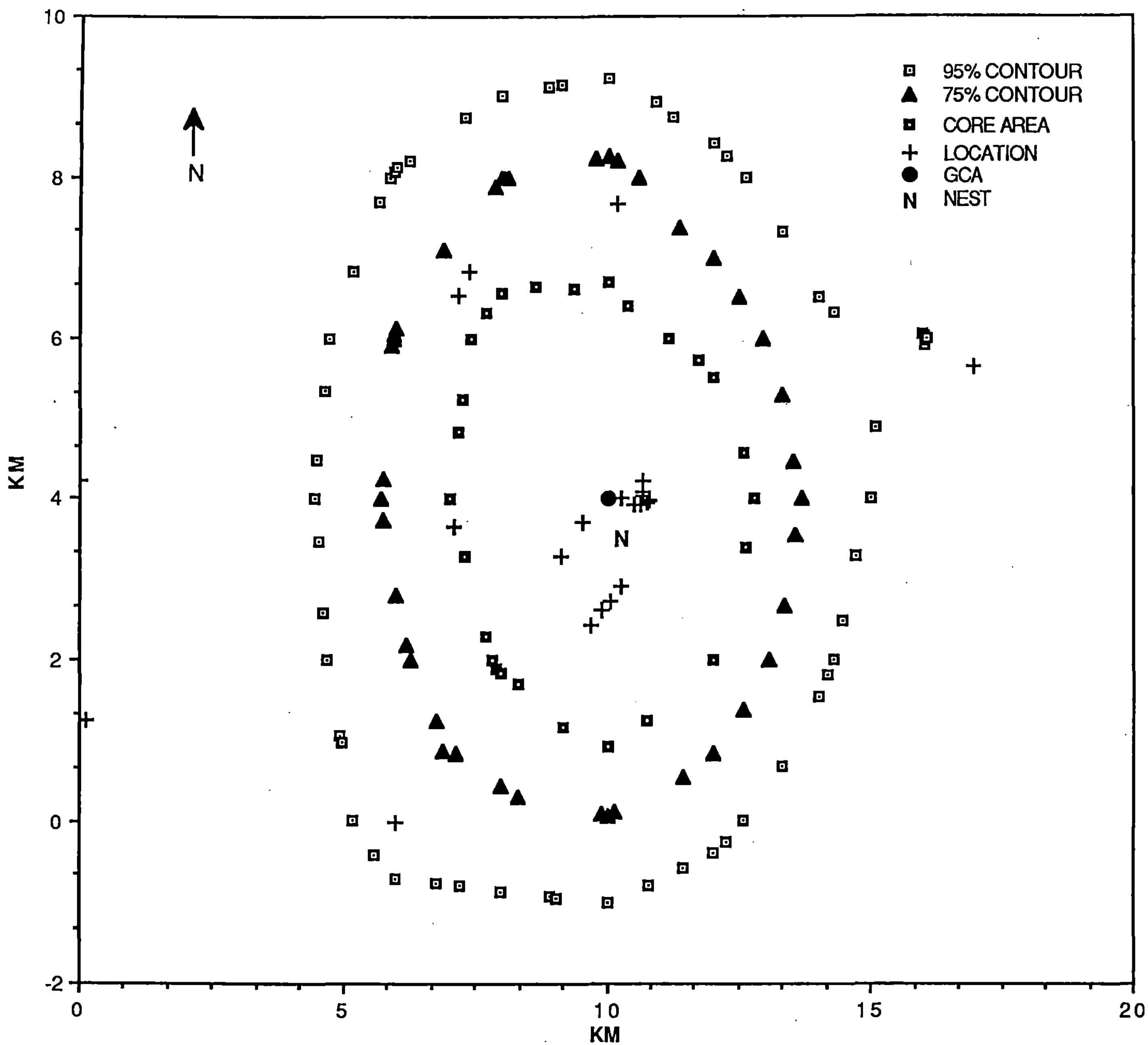

FIGURE 31. HARMONIC MEAN HOME RANGE ESTIMATES OF FEMALE COOPER'S HAWK - 31.

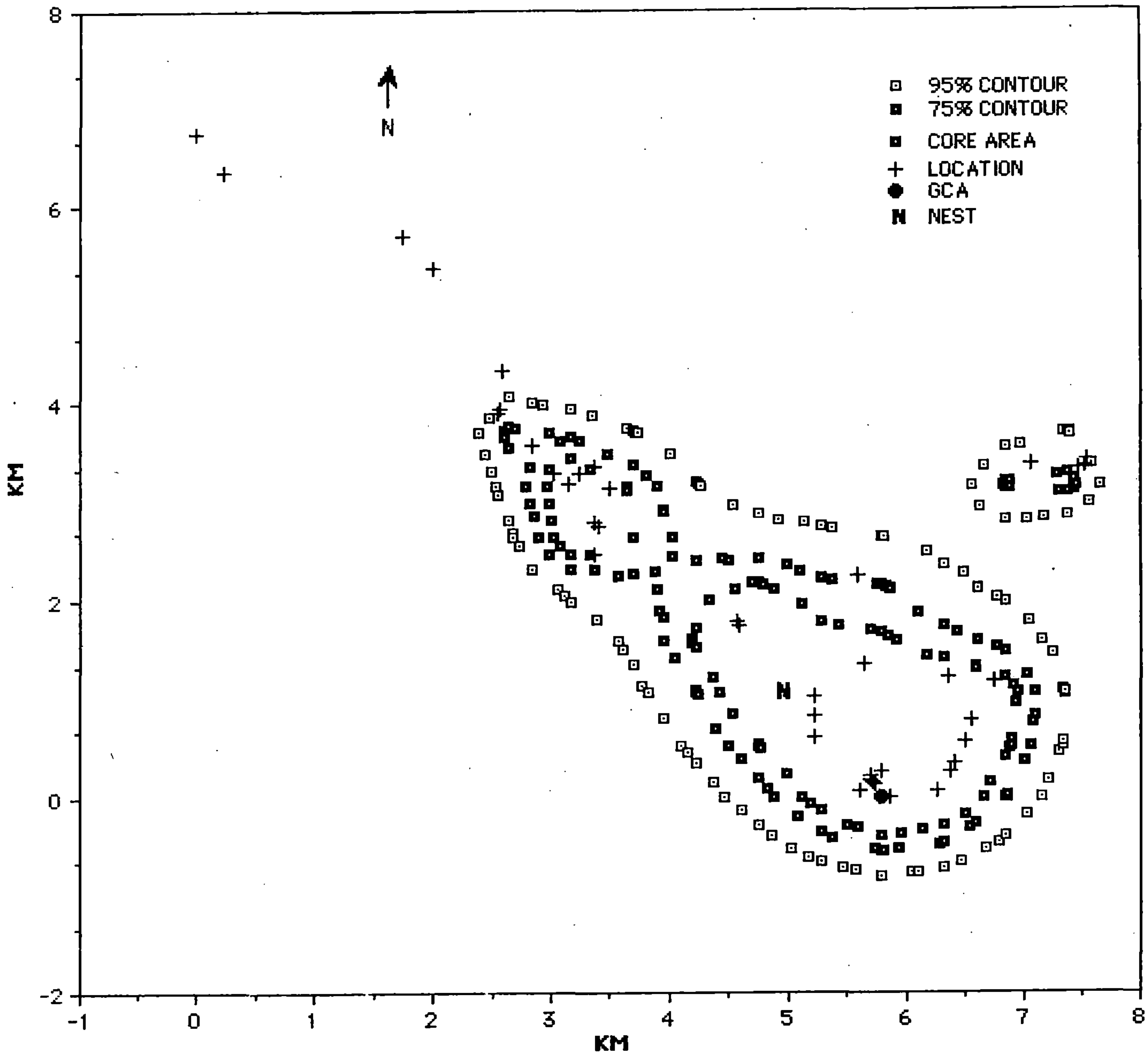

FIGURE 32. HARMONIC MEAN HOME RANGE ESTIMATES OF MALE COOPER'S HAWK - 32; MATE OF BIRD 30.